OUT OF CARNAGE

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By ALEXANDER R. GRIFFIN

New York
HOWELL, SOSKIN, PUBLISHERS

To

Niver W. Beaman,

a good friend

ACKNOWLEDGMENTS

To Commander Francis J. Braceland, U.S.N.R., of the Bureau of Medicine and Surgery, Navy Department; Major Harry M. Lutgers, Director of the Technical Information Division of the Office of the Surgeon General, U.S.A.; J. C. Green, chief engineer of the National Inventors Council, Department of Commerce; Captain Frederick S. Pease Jr., War Department; Charles Fisher, Mary MacNeill Griffin and Jean Barrett Lit the writer extends his deep gratitude for technical and other assistance.

ALEXANDER R. GRIFFIN

The Contents

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1. The Human Spirit in War

THERE HAD BEEN some shocking figures released on casualties before: the loss of all except five of her crew when the Cruiser Juneau went down off the Solomons; the toll that some of the Normandy beaches took on D-Day in France; the decimation of the Airborne troops at Arnhem; the thousands of dead and wounded it had cost us to take the tiny atoll of Tarawa and the larger, and consequently even more expensive terrain in terms of human life that was Saipan, in the Marianas. But when an official communique from Admiral Chester W. Nimitz put the American casualties on Iwo Jima at 4,189 dead, 441 missing and 15,308 wounded—a total equal to the casualties suffered on Tarawa and Saipan combined, and one higher than the number of Union casualties suffered in any of the bloody battles of the Civil War excepting Gettysburg—it seemed too much. A woman, whoever she was (the Navy did not say), sat down and wrote: "Please, for God's sake, stop sending our finest youth to be murdered on places like Iwo Jima. It is too much for boys to stand, too much for mothers and homes to take. It is driving some mothers crazy. Why can't objectives be accomplished some other way? It is most inhuman and awful—stop! stop!"

Gravely, and courteously, the Secretary of the Navy, James V. Forrestal, who had witnessed the first awful days of Iwo Jima himself there on the beach, wrote a reply. "On December 7, 1941," he said, "the Axis confronted us with a simple choice; fight or be overrun. There was then and is now, no other possibility.

"Having chosen to fight, we had then, and have now, no final means of winning battles except through the valor of the Marine or Army soldier, who, with rifle and grenades, storms enemy positions, takes them and holds them. There is no short cut or easy way. I wish there were."

It was a reply characterized by candor and dignity, born of the realization that when 32.6 per cent of the 61,000 United States Marines taking part in the conquest of Iwo Jima turned up as casualties, a new and bloody record had been established. Saipan cost us 11,247 in dead and wounded, or 23.6 per cent of the 47,634 troops who fought there, and we thought that high. Peleliu cost us 6,172, or 24.9 per cent of the 24,788 who took part there. Tarawa took a toll of 3,175 in killed and wounded, or 18.6 per cent of the 17,075 who stormed its shores. But a percentage of 32.6 in killed and wounded and missing made Iwo Jima the bloodiest campaign in all the Marine Corps' 168-year-old history, and almost enough to provoke any woman in the country to write: "Please, for God's sake stop!"

Perhaps, however, the Secretary might have eased the pain had he thought to add that as far as the wounded were concerned the chances of their recovering were also at an all-time high. Had similar or comparable casualties been suffered by the Union forces in the Civil War, the death rate among them, even after they reached a hospital, would have been 14.6. Under similar or comparable circumstances on the battlefields of the Spanish-American War, 4.6 out of every hundred would have died. Even in World War One, the death rate among the hospitalized wounded took eight men of every 100. But, in World War Two, the death rate among wounded sailors and Marines is astonishingly low.

The Navy Department reports that of the 2,191 wounded on Tarawa, 1,674 fully recovered; of the 8,910 wounded on Saipan the number fully recovered is 6,809, and of 4,974 wounded on Peleliu, 3,801 were marked off the charts as fully recovered. The overall death rate among wounded sailors and marines for all Pacific campaigns to date is 2.3 per cent.

Discussing these figures in an address made before medical men in New York recently, Major General Norman T. Kirk, U.S.A., Surgeon General of the Army, gave credit for the lowering of the death rate in World War Two to three primary factors. These were: the administration of first aid on the scene of battle; speedy evacuation of the wounded and the antidote for shock deaths that is whole blood. But he, too, might have had a word for other aids as well; aids both inanimate and human.

There were, for instance, the fourteen soldiers who ultimately received the Legion of Merit medal, who volunteered to submit to experiments which greatly increased the Army's knowledge of sandfly fever, a disease encountered by American fighting men in tropical and semitropical regions. The soldiers were all infected with the disease during the experiments. The fever was produced in some of the volunteers by small injections of blood from individuals who had it, and in others by deliberate exposure to repeated bites of infected sandflies. Sandfly fever —the medical men call it "phlebotomus fever"—is caused by the nocturnal bite of a sandfly carrying the infective agent, a filterable virus. The carrier is a fly about an eighth of an inch long, and it is only the female of the species which bites. The puncture of the skin is usually painful and in a week or two the bite area becomes inflamed and swollen.

The fever is not contagious. The only way it can be transmitted is by the bite of a sandfly that has bitten a person who has the fever. The onset of the sickness begins two or three days afterwards and results in symptoms not unlike those of influenza. The patient is incapacitated for one or two weeks, although his temperature, going as high as 102 or 104 degrees, usually subsides in about three days.

The experiments disclosed that the virus causing the fever in the Middle East was the same as that contracted by our soldiers in Sicily. The active virus obtained from Sicily was injected into healthy individuals. They came down with sandfly fever. After complete recovery, they were injected with the active virus from Egypt. This time they did not contract the fever. So it was proved that an attack of Sicilian sandfly fever would confer immunity against the virus from Egypt.

The studies, which were started in April, 1943, in the Middle Eastern Theater, were directed by Dr. John R. Paul, Consultant to the Secretary of War and Director of the Surgeon General's Commission on Neuro-tropic Virus Diseases, who was flown into the area with Major A. B. Sabin, Army virus expert, and Major C. B. Philip, entomologist. In the field laboratory which was established, six different kinds of monkeys and several other animals were tested before the experiments with the soldiers were begun, but none of the animals was found to be susceptible to the disease.

The soldiers volunteered for a second series of experiments, which resulted in the finding that two chemical insect repellents, dimethyl phthalate and pyrethrum-containing vanishing cream are successful in preventing sandfly bites. The material was applied to exposed areas of the body and found effective through an eight-hour period. In making the test, infected sandflies were released in the sleeping quarters of men who had volunteered. Only those who had not applied the repellents were victims of the fever.

Then there were the contributions of the numerous groups of conscientious objectors confined in camps all over the country, like those made by three groups of so-called "C.O.'s" to aid the Army in its battle against influenza and pneumonia. This was a voluntary act which resulted in 94 of the 122 men involved becoming ill, some of them gravely, although all of them recovered.

One of those studies was carried on by Dr. John H. Dingle, of Fort Bragg, North Carolina, at a conscientious objectors' camp located at Gatlinsburg, Tenn. There 45 to 50 men volunteered to permit their noses and throats to be sprayed with washings from the noses of seven soldiers at Fort Bragg who had the vague, but serious, disease known as "primary atypical pneumonia." This is believed to be a virus infection, but medical research, despite intense effort since it first appeared three or four years ago, has not yet solved it. Its symptoms differ from ordinary pneumonia and, unlike the latter, it does not respond to treatment with serums and the sulfa drugs.

Working with Dr. Theodore J. Abernethy, Dr. Alexander D. Langmuir, and Dr. Charles H. Rammelkamp of the Respiratory Diseases Commission, Dr. Dingle selected the twelve healthiest and soundest of the volunteers. The test material, unfiltered, but frozen in carbon dioxide "snow" for the trip from Fort Bragg, was thawed and sprayed into their noses; then they were kept in group isolation for six weeks, and examined daily.

"Respiratory illnesses, varying in clinical manifestations and severity, developed in ten of the twelve volunteers," he reported. "Three of them were quite sick and went to the hospital, but all recovered quickly and satisfactorily."

It was the first time that primary atypical pneumonia had been so transmitted and it makes important the study of the test material for the purpose of isolating the effective agent—work which is now in progress.

Work on influenza was done at the camp of Wellston, Michigan, by Dr. Thomas Francis, of the University of Michigan, and Dr. Paul R. Cannon, Dr. Francis B. Gordon, and Dr. Clayton G. Looslie, of the University of Chicago. Dr. Looslie now is a captain in the Army Medical Corps. In this case, the purpose was to test the validity of reports that inhalation of sprayed blood serum from a person who had recovered from influenza would protect the subject from the infection. The serum, it was found, did *not* confer immunity. Two tests were made. In the first, 79 volunteers served in three groups. One group of 26 inhaled a spray of plain salt water (unknowingly), then a spray of a laboratory strain of active Type A influenza virus. This was a control group. A second group of 27 men received a spray of human serum then the active virus. A third group of 26 received the serum, but the virus given them had been inactivated with ultraviolet rays.

Within from 18 to 24 hours, all the 53 men in the first two groups had influenza, recovering without complications in two to four days.

Several questions still remained, however, and a second test was set up, in which more potent serum, taken from the sickest men of the first group, was used on 31 other volunteers. Greater concentrations of serum over longer periods of inhalation were used in these men and the serum was inhaled after, as well as before, the virus. A weaker virus was also used. Sixteen of the volunteers got serum and virus and fifteen got salt solution and virus. But again all who got the active virus got influenza. However, the occurrence of high fever, 103 degrees or better, was much lower in the second group. The investigators concluded that vaccination offers more hope of protection against influenza than passive immunity through inhaled serum.

Had Major General Kirk made that particular address four months later than he did, he might also have given credit for keeping the death rate among American wounded at an all-time low to still another factor. For only this year has the Division of Medical Sciences of the National Research Council been permitted by censorship to lift the veil on a series of far-reaching tests designed to find new means of combating what the Army and Navy both have referred to as our worst enemy in the Pacific—malaria. And the prime guinea pigs on which these tests were made were several hundred prisoners in three of the country's largest penal institutions. No promise of reward of any kind was given the prisoners. To carry out the tests, it was necessary for them first to allow themselves to be bitten by mosquitoes carrying the parasite of malaria, which causes some three million deaths a year. Then, they had to expose themselves to further and even greater danger; they had to take varying doses of several new drugs to determine whether the chemicals could be safely given to our fighting men exposed to malaria and in what quantities.

Says the National Research Council report:

"The men accepted full responsibility for any ill effects, aware of the risk and discomfort to themselves and knowing, too, that despite every care, there was a real hazard involved. These one-time enemies to society appreciate to the fullest extent just how completely this is everybody's war. No fatalities were expected in the course of the tests, but the element of risk was always present. Instead of being deterred by this, many of the volunteers actually invited danger, in order to share in some measure what their friends and relatives are experiencing on the various battlefronts.

"Upon learning that, through their cooperation, thousands of GI's might be spared the ravages of the tropical malady, the prisoners responded immediately and enthusiastically. Honor-bound not to discuss the experiment and not to take medication for a chance cold or other illness, and sworn not to do anything that might interfere with the accuracy of the tests, the men have carried out their trust to the letter. In this willing spirit they patiently submitted to numerous injections and to the many tests required in the carefully checked study.

"They joked about the huge needles used for taking blood specimens, calling them 'Harpoons,' but not one refused to stay for the full course of punctures and tedious, frequent examinations. Their understanding of the importance of the work was indicated by the number who completed one two months' test and immediately offered to take another."

The report went on to say that while quinine and atabrine are very efficacious in suppressing clinical attacks of vivax malaria, neither is capable of eradicating the disease completely once a person has become infected.

"The large number of men returned to the United States with recurring attacks of this type of malaria attests to the incomplete worth of available drugs against this disease," it went on. "In the field of mosquito-killing agents the recently discovered compound, DDT, has been phenomenally effective, but no insecticide has yet been found which will kill all mosquitoes under all situations. Engineering control methods against mosquitoes, although effective in local areas, are too costly to be the complete answer to malaria in the tropics. The highest hope, therefore, is for a specific drug that will actually cure or prevent malaria."

America is a humane nation. Its people would be reluctant, on the whole, to subscribe very wholeheartedly to the doctrine of Bernhardi, who in "Germany and the Next War" wrote: "The inevitableness, the idealism, and the blessing of war, as an indispensable and stimulating law of development, must be repeatedly emphasized." Nevertheless, in its constant battle to keep casualties at a minimum, the Army has produced an occasional medical advance of marked stature.

One such was the discovery of what gives soldiers—and civilians, too—jaundice. In point of the number of people affected, this is the most important medical disease of the war. Up until January 1st, 1945, it was increasing at such a rate in the United States that it was becoming a reportable disease in many states. Jaundice, it can now be pointed out, is a filth disease transferred from one person to another through the agency of flies, polluted water and other means, in much the same way as dysentery. Therefore it is a preventable disease brought on by the war conditions, but there are special reasons why it is spreading in the United States, for other things have been discovered about it.

There have been more cases of jaundice during the war than of any other disease, and it has caused more deaths and more lost days than any other sickness. For a time in Italy, for instance, there were more casualties from jaundice than from deaths and wounds at the front. It kept men away from duty two to three months. It became so serious a matter that a "jaundice commission" was set up to make a special study of the disease and this group of eminent physicians worked on the question since July of 1943.

The most active and head of the group was Colonel Marion H. Barker of Northwestern University Medical School, Chicago, who worked with a research council headed by Major General Morrison C. Stayer of the Regular Army and Colonel Perrin H. Long. For more than a year their chief center was the Fifteenth General Medical Laboratory in Naples, where jaundice was being studied from the chemical, serological, immunological (animal experimentation) and transmissibility angle.

The first clue came to these men when they noticed a connection between the fact that German prisoners who had been fighting and living around Sirte and Bengazi in Tripolitania and later in Tunisia in 1943 and the American Thirty-fourth Division, which fought and lived over the same territory in Tunisia, both developed epidemics of jaundice. In fact, the famous Hill 609, where one of our first great battles was fought, was in a sense a center of jaundice as well. Hundreds of German prisoners who fought there got the disease. The Americans first got an epidemic of diarrhea in July, followed in the autumn by jaundice. From the Thirty-fourth Division it passed to other units.

It was noted that headquarters organizations of combat regiments and divisions got it in higher proportions than base sections or the men, nurses and officers who were taking care of the sick soldiers. That showed it was not a contagious disease in the ordinary sense. A variation was also noted with the seasons of the year when flies were prevalent and regions of the country were partially flooded. Consequently it was thought that jaundice was a filth disease and experiments were begun to test the hypothesis.

Waste matter from persons with jaundice was given to volunteers, many of them conscientious objectors. It was found that three of every five volunteers developed jaundice. Sufficient evidence was uncovered to indicate that jaundice is a virus because it was found that the blood count goes down during the disease and it has an incubation period of twenty-one to thirty days. It is almost certainly an intestinal transfer disease.

The virus itself has not yet been discovered but such advances have been made that Colonel Barker feels sure that it is only a question of time now before the germ is isolated. It is believed that there is more than one germ, because there are different kinds of jaundice. The reason why it has spread to the United States, and why its further spread after the war must be feared unless it is prevented at the start, is that it was found that the jaundice virus is exceptionally tough. It stands temperatures of 70 degrees Centigrade, while most viruses are killed at 45 degrees.

In January, 1944, only 55 per cent of the cases went back to duty after an average of sixty-five days away. January, 1945, however, saw 92 per cent return within fifty-two days—a saving of more than one-third. This is done through early recognition and care. The victim must be put to bed as soon as possible, and the number of cases has been cut down through more careful sanitation. Another important factor in the cure is a high protein diet with plenty of milk.

Still later, but so far incomplete research has indicated that certain forms of so-called jaundice will respond favorably to treatment with blood plasma.

Still another really worth while medical advance to come out of research aimed specifically at holding down the death rate among the nation's wounded is gamma globulin, used in treatment of measles.

Blood plasma, already in use on every battlefield in the world for the prevention of shock, is also the source of this material. Gamma globulin is a protein separated from blood plasma. Because it contains the so-called antibodies which destroy the germs of measles, it will, in most cases, prevent an exposed individual from developing the disease.

The complete story of the research is told in a report by Dr. Joseph Stokes, Jr., director of the Commission on Measles and Mumps. Dr. Stokes is professor of pediatrics in the University of Pennsylvania Medical School.

The work on measles grew out of the fundamental studies on blood plasma carried on by Dr. Edwin J. Cohn at the Harvard Medical School. Dr. Cohn, who is one of the world's leading authorities on the chemistry of the blood, succeeded in separating blood plasma by chemical means into its various fractions or components. One of these is the so-called gamma globulin. Studies showed that all of the so-called antibodies in the blood were concentrated in this fraction.

These antibodies are the chemical entities which establish a person's immunity after a particular contagious disease. Thus, the reason why a person who has had measles does not ordinarily get a second attack is that after the first attack his blood contains the antibodies which protect him against measles.

Since blood collected for plasma by the American Red Cross comes from thousands of persons who have established immunity against many contagious diseases, the gamma globulin contained in this plasma is, in effect, a vast treasure house of antibodies against many diseases, not only measles, but dipththeria, scarlet fever, typhoid fever, etc. Gamma globulin is now being separated from a portion of the blood collected by the Red Cross.

The Commission on Measles and Mumps, however, has been concerned only with the investigation of the use of gamma globulin as a preventive of measles. Studies made by members of the commission, all distinguished medical men, have resulted in the accumulation of data on more than 1,000 individuals, mostly in Baltimore, Boston, New York, and Philadelphia.

Most of the work was done in Army camps, but one significant study was carried on during an outbreak of measles at a girls' college in the East.

When measles appeared in a sharp epidemic at this college, gamma globulin was given to 67 exposed students who had no previous record of measles and who therefore were susceptible to it. It was not given to 38 other susceptible students. Only one case of average measles developed in the group of 67 students treated with gamma globulin. There were three cases of modified measles and eight cases of mild measles. Among the 38 students not given gamma globulin there were 18 cases of average measles and five cases of mild measles.

The gamma globulin is injected into a muscle with a hypodermic needle. Studies by the commission have established the proper dosage. For a child between the ages of six months and six years, the proper dose is from 1.5 to 2 cubic centimeters. For a child aged six to 12 years, the dose is 4 to 5 cubic centimeters. For adults, the dose is 8 to 10 cubic centimeters.

New ways to use the sulfa drugs, refinements in the use of penicillin, and countless other medical advances all have come directly out of the efforts of every agency in the country—military and civilian—to keep down disease and make it as practicable as possible for the soldier and sailor going overseas to count on a reasonable chance to survive, even after he is hurt. But also there have been mechanical advances which are specifically of aid in bringing the service man back alive.

Early in the war, for instance, a group known as the National Inventors Council was organized and placed under the Department of Commerce wing. Its prime purpose in life was to offer inventive-minded citizens a big chance to help win the war. Out of that venture has come the pocket still, used now by Army and Navy fliers forced down in tropical waters to obtain fresh water at sea. The still, a solar mechanism, converts salt water into fresh at the rate of more than a pint in eight hours. It is the invention of Richard Delano, of Locust Valley, New York. A vinyl plastic envelope folded into a pocket-sized package is blown up so that it floats. A black cellophane sponge, stretched through the middle of the envelope, soaks up water and absorbs heat from the sun. Through evaporation and distillation the salt is taken out of the sea water.

There are, too, such scientific advances as new techniques in refrigeration, so that human eyes and human nerves can be kept in banks, like blood banks, for grafting onto injured men. And there is, of course, the ultimate refinement of which the Surgeon General spoke, in the technique of speedy evacuation of the wounded. This technique has been so developed that not only are men flown out of the front line of battle in little shuttle planes and then transferred and flown clear back across the oceans to first grade hospitals here in the United States, but not so long ago, around the area of the Remagen bridgehead on the Rhine, wounded were transferred to base hospitals by gliders in a matter of five minutes.

No expenditure in money or effort is too great in the eyes of the Americans in World War Two—if it will save an American life. The humane spirit wages this war for America just as surely as the forces of destruction waged it for the Totalitarians.

2. Soul Surgery

THERE IS A faintly comforting belief that surgery and medicine advance almost automatically with any war. We know that new drugs will be found and new methods of repairing damaged bodies will be discovered; for man tries to invent new ways to save life even as he invents new ways to kill.

But the peculiar elements of World War II—size, complexity and vast mechanical devilishness—have compelled development of one scientific field to a point unknown in the whole history of men in battle. Military surgeons are deeply involved today in study of that durable, fragile and unpredictable instrument, the human mind. They have learned that a man may be grievously wounded although no bullet touches him. They have learned that the wound may be more tragic than a missing arm. And they are learning to heal the victim.

In consequence, hundreds of thousands of men who might have gone through life with vacant eyes and no capacity to take care of themselves have become useful members of their outfits and presumably prepared to take up their normal lives after the war.

The thing from which they suffered and which they were taught to conquer has many names. It has been called combat fatigue, battlefield fever, operational fatigue, battle jitters, battle breakdown and the crackup. In the last war a somewhat similar disarrangement was called shell shock. Today military medical men have labelled it more accurately as a neuropsychiatric disorder, and a complete routine has been developed to care for the neuropsychiatrics—the N.P.'s.

The illness may develop in many ways, and the treatment varies from electric shock and hypnosis to occupational therapy. A characteristic case—if anything involving subtle damage to the mind can be called characteristic—was reported in January of 1945 in the *Baltimore Sun.*

A private, Leonard Resnick of Baltimore, served with the First Division advance lines in the Tunisian campaign. In April of 1943, moving forward near the famous Hill 609, he and his fellows had dug in to await a counterattack when a German 88 shell exploded nearby. When medical corpsmen found Resnick he was conscious, but he was uncertain of his own identity, unaware of what he was doing, tormented by memories of wounded and dying comrades.

Preliminary treatment in North African hospitals brought him a measure of mental tranquility, but when he was transferred to the Walter Reed Hospital in Washington his life before the shell blast remained a blur. Although Army therapists were unaware of the fact, in private life Resnick had been amazingly skillful at carving delicate figurines out of sticks of schoolroom chalk. An Army nurse, seeking to interest him in some activity, gave him a box of water colors on day, and he slowly began to paint.

At intervals during the next few months he turned out 50 paintings of some merit. He was still working in water color at the Walter Reed Hospital five months after his injury, but his manner was listless. Then one afternoon he fell down stairs. He tripped over his bedroom slippers, tumbled down 25 steps and bruised his head. Instantly he rose, shouting: "Give me a grenade; here they come."

The blow, as in a thousand conventional tales of amnesia cases, had restored his memory. But he was taking up his life five months back, and Army psychiatrists were concerned lest worry over the gap prove troublesome later.

A new course of treatment was undertaken. Each day a psychiatrist placed him in a state of hypnosis, questioning him gently about the period gone by, advising him that he could get that part of his life back if he willed. Slowly it did come back. Resnick remembered a hospital at Oran, the nurse who gave him the water colors, spells of disinterest when he refused to join in communal hospital life, spells of battle-craze when he and his companions wanted to fight everyone in the ward.

The treatment was a long one, but in the end the pattern of the patient's life was complete; and at the time the *Sun* interviewed him he had gone back to carving, was studying art and was engaged to be married to the girl he had known before he entered the Army.

Only one confusion remained to indicate the point at which even the most adroit mental therapy must stop. Resnick, after his fall, could no longer paint. The talent which had been notable for five months vanished the instant the earlier gift, the gift for carving, returned.

Resnick's illness descended upon him suddenly and dramatically, as a result of a shell burst. In thousands of cases the breakdown comes as the result of a multiplicity of smaller factors which may trouble the soldier or sailor without his knowing it. Dr. Lawrence S. Kubie of New York, who prepared a Manual of Emergency Treatment for Acute War Neuroses, says that only in exceptional instances does a single overwhelming catastrophe cause a breakdown without warning.

"It takes time to recover from sudden danger," he wrote. "When the driver of an automobile has a narrow escape he experiences a quick sequence of feelings: swiftly mounting tension which culminates in momentary terror, relief, elation, anger and sometimes tears. . . . After a variable time there will normally be a return to the emotional center of gravity. . . .

"But when one threat is followed at once by another, the disturbances become cumulative. . . . These cumulative experiences are typical of modern warfare and are a major cause of rapid breakdowns. . . . The soldier with a charmed life knows that with every fresh escape his chances are less for the next. Consequently, each successive escape contributes to a secret mounting tension."

Dr. Kubie's cool, scientific phrasing can be related to a hundred situations of modern warfare: soldiers in foxholes living from second to second; men of a warship's crew spending weeks in active battle zones; fliers accomplishing mission after mission and wondering if they will live until they are sent back for a rest period; merchant seamen unaware of the moment when their tanker will run afoul of a submarine; Marines on Pacific islands, bedevilled by the psychological warfare of the Japanese.

There are in the armed forces, as well as in any group of humans, some men more susceptible to breakdown than others. Efforts are made to screen them out at the induction centers but the psychiatric examinations are necessarily hasty and not as successful as the Army or Navy would wish. But strong and brave men break, too—men who are to all appearances normal, and who would laugh at the idea of any weakness.

There is a record of one Marine who landed on Guadalcanal with the first wave of attackers. For more than a month he fought and worked under the most perilous circumstances; and if he felt the normal fear of men in danger of their lives, it was far from becoming a neurosis.

After the first month, however, he began suffering from headaches. In a fortnight they were accompanied by dizziness and nausea. A week later an uncontrollable trembling developed and friends took him to sick bay. He was unable to account for his condition; shells had fallen near him, but it was not a new experience and none had knocked him unconscious. Nevertheless his body, head and hands continued to shake. He lost weight, became unduly sensitive to small noises, developed a feeling that he had not done his part in the fight.

There was no question about his valor—he had consistently done more than his share—nor was there any question about his real illness. Happily his symptoms were noticed early enough and he required little more treatment than rest and psychiatric interviews to return him to health and mental ease.

He typifies the case of a brave man plagued by a disorder coming from deep within himself. His case recalls the assertion of Major General Norman T. Kirk, Surgeon General of the United States Army, that the term psychoneurotic may be widely misunderstood.

"The public confuses the term with psychosis and immediately labels him (the patient) crazy," General Kirk said. "There is nothing mysterious about psychoneurosis. It does not mean insanity. It is a medical term for nervous disorders. It manifests itself by tenseness, worry, irritability, sleeplessness, loss of self-confidence or by fears or over-concern about one's health.

"A great many of those symptoms are manifested by people in civilian life, to greater or lesser degrees. You are all familiar with the chronic complainer. Nearly everyone has some idiosyncrasy about health. In spite of all this, the psychoneurotic in civilian life is not labeled, nor does he have difficulty in carrying on his business. Some of our most successful business and political leaders were psychoneurotics.

"But put that successful, psychoneurotic business man into the Army and the doctors immediately have a problem on their hands. Our Army is for the most part a civilian army. The majority of our soldiers have had no previous military training. Our citizens have not been regimented. They are used to a beauty-rest mattress, a private bath and all of the other conveniences that have made our American way of life so desirable. Some of these men are pampered by over-indulgent mothers and coworkers from early morning till late at night.

"When this type of person is put into the Army he has a lot of adjustments to make. He becomes part of a vast machine that is regulated like clock-work. His job becomes an important part of an over-all job. He is not always in a position to know the ultimate objective of his work. So he starts to worry about it.

"He has other adjustments to make. There is mass feeding. Oftentimes he is on K rations. Sometimes he has no rations and he has to shift for himself. There is mass sleeping. The man next to him snores. Unfamiliar sounds disturb his sleep. On maneuvers he has to sleep on the ground and on the battlefront he may not get any sleep for hours at a stretch. These are all disturbing elements to him.

"Under all of these conditions it is difficult for him to adjust. It's hard enough for a rugged, hardy individual to adjust, let alone a man with psychoneurotic tendencies. Therefore the nervously inclined individual who was a success in civilian life fails in the Army and receives a discharge.

"We also have the moron, the mental defective and the constitutional psychopath to deal with. We get the alcoholic, the pathological liar and the pre-criminal in the Army. We have the boy who has been a failure all his life. He is a problem child at home and his school and occupational records have always been poor. Very few of these men ever make good soldiers.

"Then we have the nearly normal individual who cracks under combat. Everyone has his limit of mental and physical endurance. A man can stand just so much. Put him in combat and under prolonged shelling and bombing, combined with poor rations, sometimes none at all, he becomes a casualty.

"It's not the first time strong men have broken down after giving what it takes!"

The Army has as many of that type of casuality as it has of physically wounded, and the care provided is just as thorough. Indeed, both Army and Navy, working in their own fashions but drawing from the same great pool of medical knowledge, have arrived at what might be termed a standard treatment.

The treatment is based on the assumption that a neuropsychiatric maladjustment is in reality far more than battle fatigue. Many men become deadly weary under fire, only to recover under their own power when afforded a rest. But the P.N. is betrayed by his own mind and the cure lies in getting as deeply as possible inside that mind. If treatment is given at once, up to 80 per cent of the cases can be not only cured, but cured to a degree where the men are fit and ready to go back to combat duty. If treatment is delayed, the percentage of complete rehabilitation to useful military service may drop to five or ten.

Fighting men do not realize it, but their mental health is watched almost as closely in the modern Army and Navy as their physical well-being. Many officers have received courses in what might be termed observant psychiatry; they are trained to watch for the first signs of actual breakdown.

Moreover, the Office of the Surgeon General has instructed every medical officer in the Army to be alert for patients sent in from the line for treatment. For the cure must begin as swiftly as though the patient were suffering from a bullet wound.

The first specific is instantaneous rest. This is insured by use of drugs—not morphine or any other soporific, but a powerful sedative which relaxes the patient, leaving him conscious and yet dulled mentally to the sound and smell of battle. In a sense, he comes out of hell and floats on a cloud in an atmosphere wherein nothing matters much for the time being.

While he is in that state the attendant medical officers—or a trained psychiatrist, if one is available—talk to him and encourage him to mumble about his own troubles, if he cares to. He is assured that he has nothing to fear because his nerves are shaken. He is told that his fellows and his officers know that he has done his job in a way which makes him a credit to his outfit. The whole preliminary treatment is designed to restore his needed self-assurance.

In mild attacks, the patient may fall into a natural sleep and be restored in 24 to 48 hours. In that event he is sent directly back to the lines; further nursing may actually do more harm than good. But if the illness is more serious he is sent to an evacuation hospital.

There again the treatment begins with rest. Continuous heavy doses of sedative drugs are administered, until a combination of drug and exhaustion brings on a deep sleep. Men have been known to sleep three days and three nights after being brought in from battle.

When he awakes, every effort is made to keep him from falling into an attitude of self-pity. One of the symptoms of psychoneurosis may be a desire to reject war and return to a state of childhood, demanding all the nursing and attention a baby might require. The attitude is dangerous to the patient, and to counteract it he is made to stand in line for meals, to take care of his bed and personal belongings, to keep himself neat and soldierly.

In the meantime hospital psychiatrists talk with him daily. There are two purposes of the conversations. First, the victim is told precisely what his trouble is and assured that he will eventually get well. Second, the physician attempts to learn what the root of his trouble is.

Several classes of mental illness develop under the strain of active service.

One is marked by edginess and anxiety. Fighting continues in the patient's dreams, and he lives in spirit with the cries of wounded comrades still sounding in his ears. Another is a form of hysteria, marked by loss of control of arms or legs, or even by temporary hysterical blindness. (Hysteria was the shell-shock of the last war; it is one of the least common of all neurotic ailments of this.)

Another is deep self-distrust: a feeling of weakly giving way to fear, to be abolished only by repeated assurances that all men are afraid during battle and that the emotion is not weak.

Curiously, there is scarcely any danger of malingerers getting away from battle by posing as victims of true nervous disorder. The P.N. is unquestionably ill—ill beyond his own need of explanation, as ill as a stretcher patient suffering badly from a physical wound. During his period of hospitalization, physicians and nurses attempt to bring him back within the orbit of commonplace life by giving him commonplace things to do—gardening, poultry-raising, carpentry, varied kinds of handicraft. In many cases music has proved extremely helpful.

A bomber pilot in the South Pacific had his plane badly shot up while on his fiftieth mission. The men in his crew took to parachutes but the pilot crash-landed and escaped alive. He had made more than a dozen crash-landings before. But this one occurred on a lonely island manned by a Japanese garrison.

The pilot took to the jungle. By some miracle of courage and skill he contrived to kill all the enemy, taking them one by one as they sought him. Later he was rescued. He had been tough and brave until the last mission, but the lonely terror of his life on the island broke him. When a rescue group found him he was in need of intensive mental treatment.

For a long while it proceeded slowly. Eventually, however, someone discovered that in civilian life he had been a jazz musician. As soon as an instrument was found for him to play recovery began. At last report it was not yet complete, but the chances were he would be able to go back to active civilian life.

Many patients who are not musicians react well to music, and part of the conventional neuropsychiatric treatment involves fitting music to patients, seeing to it that everything from symphonies to swing are available for men who will benefit by them.

It is through treatment by drugs, however, that the most sensational cures seem to be effected. The technique has been described in detail by Lieutenant Colonel Roy R. Grinker and Major John P. Spiegel, of the U. S. Army Medical Corps, in a paper prepared for the Chicago Institute for Psychoanalysis.

Colonel Grinker and Major Spiegel suggest intravenous injections of sodium pentathol, "which induces a state of seminarcosis during which the patient is able to live through his traumatic battle experience."

"The treatment," the officers continue, "causes the patient to re-experience the intense emotions which were originally associated with the actual battle experience, and which were perpetuated in various stages of repression up to the moment of treatment. At the same time the action of the drug enables the patient to deal with those revived emotions in an economical and rational manner rather than with catastrophic defensive devices which end in serious neurotic crippling."

The "defensive devices" may include a stage of chronic melancholia wherein the patient broods over his wrongs; a stage of fantasy, wherein he imagines his own perfect world; or a stage of retreat from life, wherein he seems to seek an insensate, vegetable existence.

In any event, once the drug is injected, the patient is encouraged to believe he is again on the battlefield, so that he will talk freely of the experiences which distressed him. Sometimes the initial results are scarifying or, occasionally, pitiful. Colonel Grinker and Major Spiegel say:

"It is electrifying to watch the terror exhibited in the moments of extreme danger such as at the imminent explosion of shells, the death of a friend before the patient's eyes, or the absence of cover under a heavy dive bombing attack.

"The body becomes increasingly tense and rigid; the eyes widen, and the pupils dilate, while the skin becomes covered with perspiration. The hands move about convulsively, seeking a weapon, or a friend to share the danger. Breathing becomes incredibly rapid and shallow. The intensity of emotion sometimes becomes more than they can bear and frequently at the height of the reaction there is a collapse and the patient falls back in bed and remains quiet for a few minutes, usually to resume the story at a more neutral point."

Nonetheless, the psychiatrists hold that precisely such a release and unburdening is necessary if the victim is not to go through life with the terror buried deep in his mind.

"Here the medical officer is required to play a variety of roles," the Grinker-Spiegel report continues. "When the patient becomes convulsed with the violence of the terror he must step in as a protective and supporting figure. . . . When intense grief and anger is exhibited over the death of a best friend or guilt over the killing of a young German soldier, the patient frequently throws himself into the arms of the therapist who sits at the bedside, as if seeking forgiveness and consolation from a kindly parent."

Even cases of hysterical deafness or paralysis can be cured by the sodium pentathol method, Colonel Grinker and Major Spiegel have found. In some instances limbs move or sight returns naturally. In others, the therapist must order the patient to talk, hear or move his limbs.

Dr. Kubie, in his manual on treatment for neuroses, says specifically that there may be rage against officers, against fellow soldiers, or against subordinates. This may present difficult problems; but here again through an attitude of sympathetic and understanding listening the man must be made to understand that he has a right to his feelings, whatever they are. This must precede any effort to correct a mood. Particularly when one is dealing with rage, it is important to listen with sympathy many times before risking a demurrer to the least of the patient's charges.

In some Army hospitals the electric shock treatment is used instead of injection of drugs, because of the fear many patients display at sight of a hypodermic needle. The shock treatment throws the patient into unconsciousness and a mild convulsion, after which he has a relatively lucid spell when he can talk his heart out and listen to his therapist.

Of the shock treatment, Dr. Kubie declares: "Electric shock would seem to have many significant practical advantages, although its therapeutic efficacy in these situations remains undetermined. It is reasonable to raise the question whether the retrograde amnesia so often induced by electric shock may interfere with its therapeutic value and contribute to an elaboration and extension of the amnesic problem of the traumatic neurosis itself. This can be determined only by experience."

One characteristic and amazing example of the use of pentathol was reported in the February 1945 issue of *Flying* magazine, in an article by Nancy H. MacLennan. A pursuit squadron leader fell into an aggravated state of psychoneurosis after seeing his wingman shot down on his 25th mission. Under influence of the drug, he was told he was still on the mission which had caused his breakdown.

In two treatments, the story came out. His wingman, a friend, but a man of a competitive nature, had pulled out of proper flying position in what the patient believed was an effort to steal the squadron lead. The patient refused to move his own plane out of correct flying order. In that moment his friend, shouldering ahead, was struck by flak and went down flaming.

The medical officer who treated the case explained that the patient was incorrectly assuming responsibility for his friend's death. After many talks the flier became convinced that he was not to blame. The moment his self-approval was restored he went back to his job.

Both the Army and Navy medical corps believe the first duty of a medical officer is to get a man back to his job when he is physically able to take it up again. When this measure is manifestly impossible, they concentrate on re-adapting him for civilian life.

Colonel William C. Menninger, Army Medical Corps, who is in charge of the Army's mental hygiene program, has talked like a Dutch uncle to the medical officers on occasion, in his insistence that psychiatric elements be taken into account in all diagnoses. In an address before the Association of Military Surgeons in November of 1944, Colonel Menninger said medical officers would have to learn to evaluate the emotional factors in disease.

"This is a particularly significant factor for those of us (medical men) in the Army," he said. "Too many physicians develop an attitude of irritation and annoyance which even reaches a vindictiveness toward the patient never manifested by that same medical officer in civilian life.

"We have become familiar with the common verbal expression of this irritation in such remarks as 'The bastard isn't going to get away with this,' or 'He should be shoved up in the front line trenches,' or 'It is too bad all the good boys have to be shot.'

"This attitude is highly emotional and unscientific, but it is not so difficult to understand. . . . If we are to understand this attitude, we must investigate ourselves. At least 95 per cent of the present medical department of the Army is composed of men who were in civilian practice until the present crisis. At least 90 per cent of this group still have their interest in and their preference for their civilian jobs. . . . They consciously accept their present assignments, but one cannot ignore the fact that it is not their first love nor their first desire. Not far below the surface is resentment toward the world order that rooted them out of their homes, separated them from their families. Further, probably no single group in the Army has suffered the economic losses with all its concomitant problems experienced by medical officers. . . .

"Most of us continue to be perplexed as to how to meet our insurance, how to pay for the X-ray back home, what has happened to our patients, how much money the other fellow is making, when are we going to get back home. Consequently, it is not surprising that the clinical judgment of some medical officers gives way to the subjective though unadmitted emotional feeling expressed in the attitude of 'If I can't get away with it, by the gods, neither will you.' "

Much of Colonel Menninger's plain speaking was designed to support his thesis that the uncured N.P. is a problem to his company commanding officer and a detriment to the efficiency of the Army as a whole. Diagnosis and treatment are as essential to the welfare of the country as to the patient himself.

Army and Navy officers have evidently been dealing with the N.P.'s—however inadvertently—since men began to fight. Commander Francis J. Braceland, U.S.N.R., of the Bureau of Medicine and Surgery in the Navy Department, believes that "unrecognized emotional disturbances have existed in large segments of military forces since time immemorial."

"In the works of Herodotus," he wrote in a pamphlet on Neuroses and the War, "one finds an interesting reference to what may have been a war neurosis. In describing the battle of the Marathon, Herodotus speaks of one Epizetus, a warrior who while fighting valiantly in the medley suddenly became blind even though he had not been struck or injured in any way.

"From the accompanying description it is plain to see that Epizetus suffered from what we today would consider a typical garden variety of hysterical blindness, a form of conversion hysteria, a psychoneurosis."

Commander Braceland points out, however, that despite a strong tendency toward emotional and nervous disorders, the actual incidence of real mental disease in World War Two is lower than had been expected. He confesses that the true psychopath, the constitutional psychopathic inferior, constitutes the same sort of problem in military service as he does in civilian life. "At present," the commander declares, "he and his kind are unsolved riddles in psychiatry."

N.P.'s are relatively minor riddles and their cases are certainly not beyond solution, but if the Army and Navy were to deny them treatment and the sympathy which a real illness demands, they would bring home a major problem to civilian life. This is not the first war in which the situation has been observed; in World War I a few psychiatrists were on duty with the A.E.F. Their sparse data provided the first recorded scientific observation of a great mass of men under strain. In fact, the figures they were eventually able to prepare are far more detailed than any figures which will be available until World War II has been a matter of historic record for years. But they indicate, these earlier tables, the differences between the breakdowns a quarter of a century ago and the situations faced by military medical men today.

The *Psychological Bulletin,* in a paper by Dr. William H. Dunn of New York, reported in 1941 that half the psychoneurotics in the American Army broke down within a month of induction in 1917 and 1918. A total of 84.5 per cent were detected within six months. Predominant in the later nervous collapses was the form of hysteria known as shell-shock.

In the present war the principal concerns of service authorities are the breakdowns which occur a year, or two or three or more years after induction, and, as has been said, shell-shock is of relatively rare incidence. A difference in the national approach to the two conflicts may be partly responsible for this difference.

America moved into World War I almost in a state of innocence. The bulk of the living generation had not known a war and the soldiers went off in a frenzy of band music and flag-waving. Even before they left, their emotional pipes had been flushed by Liberty Bond rallies, Community Sings, Four Minute speakers and a great litter of paraphernalia more suitable to an Elks' picnic than a war.

A variety of outlets for release, coupled with a certainty of our destiny, helped ease the strain of separation from family and subjection to military discipline. The men who might be classed by a layman as congenital psychoneurotics broke early. Those who carried through to the battle fronts offered no grave problem until they succumbed to the unmistakable half-madness of shell-shock.

The picture of the soldier or sailor of today is vastly different. Hundreds of thousands of men went into the services at a time when they had scarcely a thought of conscription—many before the attack on Pearl Harbor. Almost all accepted their duty knowing they were part of a machine moving with power unfestooned by excitement or open anger. The war was a hundred times bigger than even World War I had been. One year ran into a second, and a second into a third; and each year brought an increase in peril and rigor.

Men reached the breaking-point without knowing it. Consider the case of a Marine who had fought through swamps and slept in muddy foxholes for weeks on a Pacific island without showing any trace of impending collapse. One morning he looked up and saw a Japanese taking aim at his closest friend. He laid his rifle on the Jap and the rifle jammed. The enemy soldier fired and killed his friend. The Marine was struck dumb. In that instant some control center in mind or nervous system was jammed and he became as acute a hospital case as if he had been shot through the shoulder.

Fortunately, in the interest of precisely such cases, a Navy hospital for mental patients has been set up in the South Pacific. Fifty per cent of Marine patients treated there have not only been cured, but have been returned to combat duty, and it is almost certain that the percentage of swift and complete cures will increase. The Navy, like the Army, is moving psychiatrists into the front lines along with fighting men.

In many branches of the services the medical men have gone out of their way to seek risks—in order that they may know something of the situations their patients face. The flight surgeons in the Army Air Corps are expected "not only to accept, but to seek dangerous missions," in the words of Major General N. W. Grant, AAF Air Surgeon.

One aviation psychologist left Washington to fly with the Flying Fortresses in order to see how psychological tests were working out in practice. Surgeons have flown on observation missions in most parts of the world. One was in the group General Jimmy Doolittle led in the first raid on Tokio.

In general, psychiatric observations of medical officers in the front lines are part of the basis for the Army's and Navy's courses of treatment. As an example of the type of report brought back and published for the use of others, it might be well to examine at length a paper by Captain Herbert X. Spiegel, M.C., on the Tunisian Campaign. It is an uncommonly acute and sympathetic and disturbing document.

"To understand better the psychiatric casualties among combat infantrymen it is necessary to appreciate to some extent the almost unbelievable rigors and hardships they must endure," he wrote in the *American Journal of Orthopsychiatry* (1944). "There is a rather weird mixture of waiting, tension, boredom, confusion, furious activity and monotony. . . ."

"On the battlefield, what motivated these men to push forward? There was one place where war lost a considerable part of its abstractness and became acutely personal. Prior to his first exposure to enemy gunfire, the average soldier's chief concern seemed to be: 'How am I going to meet it?' 'Will I be able to control myself?' 'Will I do what they expect of me?'

"Then after the first few hours this uncertainty began to change to mounting confidence in his reputation with the others. Eventually his concern centered more about the probability of being killed or wounded. The battlefield became a fantastically real place where men strongly began to feel the utter finality of being killed; they began to compare in their minds the relative advantage of a wounded arm versus a wounded leg, or a blown-off leg versus a blinded eye.

"These men did not feel like glamorous and glorified knights of valor dashing forth disregarding danger to rid the world of evil. Nor were they, as many like to believe, a gang of rough, tough fellows who just loved to fight and went out of their way to find a scrap. They did not even express much real hate for the enemy. Instead, they were very sober, intensely realistic, peace-loving citizens who preferred a baseball field to a battlefield. At the time, however, they were serving in our army, in a large measure as a result of selection. They were acutely aware of the dangers ahead, but nevertheless they attacked and pushed forward because they were commanded to do so. They realized there was a tough job to be done and it was now their turn to contribute, at the same time keeping an eye to one side to see what the other fellow was doing. As one said, 'I see my job and I'll do it; I hope that the other fellows do their share too.' By 'other fellows' he did not mean so much the men actually at his side because he was sure of them. He meant the men in back of his outfit, and the men in back of them along the thousands of miles of land and water to the rear. Perhaps such concern made it harder, but the important thing is that they pushed forward as ordered.

"If abstract ideas—hate or desire to kill—did not serve as strong motivating forces, then what did serve them in that critical time? What enabled them to attack, and attack, and attack week after week in mud, rain, dust, and heat until the enemy was smashed? It seemed to me that the drive was more a positive than a negative one. It was love more than hate. Love manifested by 1) regard for their comrades who shared the same dangers, 2) respect for their platoon leader or company commander who led them wisely and backed them with everything at his command, 3) concern for their reputation with their commander and leaders, and 4) an urge to contribute to the task and success of their group and unit.

"In other words, the interpersonal relationships among the men and between the men and their officers became more intense and more important. These cohesive forces enabled them to identify themselves as part of their unit. It enabled them to muster and maintain their courage in the most trying situations. It even led them at times to surprise themselves with gallant and heroic actions. They seemed to be fighting *for* somebody rather than *against* somebody. For example, when our Pioneer Platoon Leader was wounded in the shoulder and had to be evacuated, he protested with tears and begged to stay, not because he wanted to go out and kill anybody, but because, as he put it, 'I just can't leave the fellows now; they need me.' Or again, our young Supply Officer who, after two days and nights of constant work getting food and supplies up to his men under most difficult conditions, asked his medical officer for benzedrine to keep him awake instead of trying to get a few hours of sleep. They were fighting for themselves and their unit, and in that way, for their country and their cause."

Captain Spiegel found conversion hysteria (shell-shock) rare, and came to a conclusion that fine leadership might actually avert psychoneurotic breakdowns in some cases, "enabling men to control their fear and combat their fatigue to a degree they themselves had not believed possible." One definite psychopath, he said, was cited three times for gallantry in action.

Some while later, in a Pacific campaign far from Captain Spiegel's observation, another psychopath received the Navy Cross for gallantry. He was, however, retired home for treatment when he told a story in this wise:

He had long felt that he was, in the old slang phrase, behind the eight ball. He was so used to being there that he got to talking to the eight ball—and the eight ball began talking back to him. They held long conversations.

On one occasion, ordered to advance with his outfit, he asked the eight ball what to do and the eight ball suggested that he lag behind and, at a certain point, turn around and go back to his base. He was agreeable, but upon turning he found that the Japanese had worked a familiar trick; they had let a small patrol go through and were then in the act of following it up. The psychopath, as he reported later, asked his eight ball what to do.

"Kill 'em!" said the eight ball, and he did.

The customary situation of the P.N. is by no means so extreme as that of the soldier and his eight ball, and yet one-third of the medical discharges from the United States Army are due to mental disturbances. The figure will probably be cut in the future, by means of early diagnosis and treatment, and through development of rehabilitation centers for those whose war wounds are not physical.

The Army Air Forces are experimenting on a large scale with a rest plan, which brings fliers back to the United

States after a certain number of missions, before normal tenseness and irritation have had a chance to develop into actual neurosis. It is a bold experiment, unique in military history. The men are brought to Atlantic City, New Jersey, or to Miami Beach, Florida, and quartered in the finest of luxury hotels. Discipline is cut to a minimum; no bugle wakes the flier and he goes to bed pretty much when he pleases. During the greater part of the day he may swim, have dates, lunch and dine anywhere his fancy indicates. All manner of sports are available to him, along with theaters and movies and the hotel dance floors.

But once each day he must keep an appointment with the military psychiatrist to whom he has been assigned; and there he "unwinds" through long, intimate discussions about his past life and his future in the Army. If he is to go back to active service, re-assignment to whichever war theater he prefers is made when possible. If it is necessary to retire him to civilian life, he is directed into the channel for which he is best fitted. There is better than an even chance that after a few weeks of sunshine, rest and mental probing a healthy, normal mentality will be restored.

One flier, interviewed by the *New York Times* at Miami Beach, gave an accurate general picture of the condition of the "mental convalescents."

"No, they said, they wouldn't exactly call themselves jitters, but all the same they were damned glad to get back," the *Times* reported. "You do find yourself getting irritated over little things after you've covered the 'Purple Heart corner' in a Fortress formation for a while.

"You know how you feel after a raid over Wilhelmshaven or Kiel, with the anti-aircraft guns sending up black feelers for you and the Messerschmitts stinging angrily at your nose? You just fall out of your plane—that is, if you get back—so damned tired that you don't even claim a probable plane shot down, just to avoid the interrogation. Know what it's like to see some guy you were kidding with two hours ago fail to come back?"

Most men agree that the course is more like a vacation than being in the Army. In the case of Air Forces fliers, Colonel Norman R. White declares:

"Aside from the changes brought about by high altitudes, flying has no different physical effect than any other service. But the air warfare is fought under great tension and produces nervous fatigue which sometimes is not noticeable on the surface.

"The surgeon looks for it in deviations from the normal—a man who formerly had a good appetite will pick at his meals; a sound sleeper will have bad dreams and lie awake; a conservative, well-balanced fellow will start drinking too much."

The course, basically, is preventive. It is dedicated to avoiding development of real, dangerous neuroses. One authority has explained that all men, civilian or military, show at times such nervous reaction as fear, anxiety, hysteria, fatigue, confusion and even obsessions. The condition does not become actually neurotic, however, until the symptoms assume powerful and controlling proportions.

War increases the likelihood of dangerous development. It supplies inner conflicts which all fighting men must solve—conflicts between a sense of duty to the country and desire for self-preservation: between the desire for self-assertion and the necessity of submitting to military regimentation. The object of all treatments, whether they be drug sedation, hypnosis, psychotherapy or psychoanalysis, is to "give the patient insight into the causes of the mental distress and to desensitize him against it."

One example of the thoroughness with which a patient's mind is explored is given in the case history of a member of the Marine Corps. The case was reported by Commander George N. Raines (MC) and Lieutenant Lawrence C. Kolb (MC) in an article on "Combat Fatigue and War Neurosis" in the September, 1943, issue of the *Naval Medical Bulletin*. The report:

This 24-year-old lieutenant had one year and sixteen days' active duty in the United States Marine Corps prior to his admission to the hospital for study concerning an "emotional instability."

At birth he lost his mother and was placed in the hands of an aggressive but affectionate aunt and a colorless uncle. As the only child in the home, he was pampered and spoiled, but at the age of eighteen years decided to return to his very successful father, who had meanwhile married and had two children by his second wife. The readjustment was difficult but successful; at first he felt resentment toward his stepmother, who seemed unduly critical and appeared to discriminate against him. He entered college in accordance with his father's wish. He pursued a dilatory course, though active in athletic and social affairs. However, on the side, he methodically and conscientiously carried out a research program for a chemical company as a means of obtaining funds for himself.

The patient left college to enter Marine Corps aviation when the opportunity presented. He had had over 200 flight hours prior to his transfer to a Pacific island base in April of 1942. There, due to equipment limitations, the group obtained only a few hours' flight per month and did not have the opportunity for combat practice as a unit. He was quartered with, and became unusually close to, his commanding officer. The patient was a member of the dive bomber unit attacking the Japanese fleet in June. His oldest companions in the squadron were shot down in flames before his eyes, his commander and a large proportion of the squadron were lost. He put his bomb on an aircraft carrier before returning to base and then was exposed to shelling by a submarine during the following night. Shortly after the return of the survivors, both he and his surviving squadron mates presented evidence of an intense emotional reaction. He was restless, tense, irritable, and unable to sleep. At night he repeatedly recapitulated the horrifying combat experiences in dreams and during the day was unduly upset by sounds reminiscent of bombing. He commenced to drink, was morose, reticent, and irresponsible and ignored the usual courtesies given senior officers. His confidence in his flying ability disappeared, he was fearful of killing himself or others, and repeatedly considered various schemes for self-injury in order to escape from the distressing situation. After a rebuke by his commanding officer, after collision of a plane in his three-plane section with an Army plane, his anxiety became so marked that he demanded to be transferred to an infantry company. In rapid succession he received three changes of station in the succeeding four months, finally ending in an infantry company. These transfers served further to undermine his security. He believed from comments made that an effort was being made to oust him from the corps.

On admission to the hospital he was anxious, restless, overactive, and sleeping poorly. He had feelings of guilt and was sheepish over a recent award of the Navy Cross. He stated that he was unable to attend movies containing battle scenes. "The first thing you know, you are right up there in it." Under treatment the patient regained his composure, was again affable, enthusiastic, assured and pleasant. The nightmares subsided, startle was less pronounced, he was able to attend movies, resumed aviation gunnery practice, and repeatedly expressed his desire to return to aviation though not certain of his ability to perform as a fighter pilot. Accordingly after three months he was brought before a Board of Medical Survey and recommended for return to limited active duty with ground aviation for a minimum of six months prior to reconsideration for flight service. The diagnosis was combat fatigue.

Comment: This rather immature lieutenant, previously without symptoms of emotional instability, with an inadequate training period prior to a dive bombing attack in which his commanding officer was killed, developed nightmares, anxiety, response to startle or to recapitulations of combat scenes in movies, and a personality change characterized by morose irritability, alcoholism, irresponsibility, insecurity, and lack of confidence. The symptoms were aggravated by the undermining influence of a rapidly changing environment and of an unsympathetic misunderstanding attitude of both medical and line officers who contacted him following the combat experience.

Another and more shocking case concerned a 17-year-old sailor who had had just seven months' active duty before being admitted to the hospital for treatment for what was at first believed to be a head injury. He was the son of a shell-shocked veteran of the last war, and an alcoholic and chronic complainer, and a mother who was irritable with migraine headache. Nevertheless, the sailor was not originally believed to be temperamentally unstable.

After his enlistment in the naval service, he received three weeks' basic training and was detailed aboard a transport for drill in amphibious operations. The patient had hoped for duty aboard a combat ship of the line.

Three weeks prior to the departure of the convoys for the North African engagement, he was transferred to another ship. There he was barely acquainted with his new shipmates when the engagement opened. His immediate chief was regarded by him with little respect as an "old man." The seaman was extremely apprehensive as his landing boat approached the beach during the opening fire, but quickly regained composure when not exposed to fire. The next day he was frightened to the point of believing his legs were paralyzed when an enemy plane strafed the ship and he threw himself on the deck. The fourth day the ship was suddenly torpedoed. He was blown against the bulkhead and struck his head, but was not injured and quickly climbed down a net into a tank lighter below. While throwing out lines to men struggling in the water he was fascinated by their cries and amazed to see some cast aside their life jackets. After helping one man aboard, the patient felt so weak that he lay upon the deck and later had to be assisted ashore. The next day a plane killed a French woman in town and he morbidly examined her body and the leg wounds of a sailor wounded in the same raid. He then realized how tense and anxious he felt, and in the following weeks had difficulty in sleeping, being repeatedly awakened by dreams in which his ship was torpedoed or he was shot in the leg. While aboard the transport returning home, he and the men in his division were quartered in a forward compartment. During a prolonged storm the group repeatedly rushed to the boat deck in panic when a loose hatch cover slammed above them. He received a 30-day leave after arriving in the country but the change in his personality was so conspicuous to his family that his mother shortly sought medical advice concerning his symptoms.

On return to duty the patient complained of headaches and dizziness, and was transferred to this hospital for study. As there was no evidence of organic disease, psychiatric examination was requested. His extreme restlessness, mounting to agitation, his inattentiveness and irritability were immediately apparent. He was unable to concentrate, expressed death fears, and presented the history of nightmares and sensitivity to sounds reminiscent of combat. His sleep was broken almost nightly by terrifying dreams. With sedation and psychotherapy there was some diminution in the restlessness, the insomnia, and his response to startle. He put on weight, but continued to complain and insisted upon his instability to return to duty. It was evident that he would not again adjust in the service. On a mental test he attained an intelligence quotient of only 69. Accordingly, he was brought before a Board of Medical Survey and recommended for discharge under the diagnosis of psychoneurosis, anxiety neurosis, incurred in the line of duty.

Comment: This dependent, youthful seaman, with a dull mentality, who was raised in a discordant home by a neurotic, alcoholic father and a highstrung mother, presented no evidence of emotional instability prior to his traumatic combat experience. He then developed nightmares, startle, and a personality change marked by agitation, anxiety, and preoccupation, with the complaints of headaches and dizziness. The case study illustrates the importance of a psychopathic background, and the contributing factors of inadequate training, indifference to leadership, and low morale. The repeated panics during the voyage home have probably further served to deepen the patient's anxiety by the process of conditioning.

In the case of a 28-year-old Marine corporal, the patient was a member of a Marine unit at the time that the Japanese attacked Pearl Harbor. As he and members of his company were leaving the mess hall they observed some planes dropping torpedoes and thought that they were witnessing a sham maneuver, until explosions took place and the planes commenced to strafe the fields. The patient, with some companions, immediately rushed to a storeroom, broke out a machine gun, mounted it near the hospital, and manned the gun during the succeeding attack. He witnessed the explosion of the U.S.S. Arizona, saw men in his company shot down by the strafing planes, and was later nauseated as the burned and maimed were carried into the nearby hospital. For the next 36 hours his company was busy preparing and manning machine gun positions upon the beach while awaiting an expected invasion. The company was kept active for a period of three weeks, and as the tension decreased the patient developed anxiety, was unable to sleep well, commenced to have nightmares which awakened him in extreme apprehension with palpitation, choking, and dyspnea. Following exposure to any sharp sound suggestive of an air raid he felt weak, sick, tremulous, and perspired freely. He made no complaint and continued duty. As his symptoms persisted for months after his evacuation to this country he became morose, irritable, restless, depressed, and fearful of developing a "nervous breakdown." For this reason, the patient sought medical advice in October, 1942, ten months after his combat experience.

On admission to the hospital there was no evidence of physical disease. He was conspicuously restless, tense, anxious, resentful and irritable, he had difficulty initiating sleep, and then frequently awoke during the night. The patient was unwilling to discuss his experience at Pearl

Harbor, though induced to give a chronological account of his activities. He was thought to be actively repressing certain of his experience and never produced dream content.

With psychotherapy and sedation, he became more composed, was able to perform simple details about the hospital compound, gained weight, slept soundly, and conversed with ease on subjects other than his battle experience. This subject immediately aroused his anxiety, and he became irritable, anxious, flushed, and excited. In spite of continuous treatment over a period of three months his improvement was considered insufficient to allow his return to even limited duty. Therefore a Board of Medical Survey recommended his discharge under the diagnosis of psychoneurosis, anxiety neurosis, considered to have been incurred in the line of duty.

Comment: This patient was observed to suffer anxiety seizures many months prior to the outbreak of war. His single battle experience, coming as a surprise and without adequate preparation, resulted in aggravation of this already established neurosis.

The fact that an N.P. can collapse after acts of conspicuous bravery is illustrated in the career of a 31-year-old ensign aboard an armed transport. He was assistant to the executive officer of the ship, despite his junior rank, because of previous sea experience.

In August of 1942, while the ship was running trials, he felt run-down and fatigued, and was at times so depressed that he had uncontrollable weeping spells. For this reason, he spent a full week in bed in the sick bay. Nevertheless, he resumed his duties when the ship joined the North African invasion fleet. Early one morning nearing the African coast, the ship was struck by a torpedo which exploded the after magazine, wrecked his gun, and threw him some fifteen feet. In spite of fracturing his back, he ordered his men to another gun, and painfully dragged himself into the wrecked compartment below, from which steam was escaping. There he heard the cries of injured men. Suddenly the patient was shocked by contact with the mangled and dismembered bodies of his own men. A half hour later the patient entered the sick bay in shock secondary to the back injury, but recovered quickly and was again at his post two days later. Throughout the succeeding three weeks the ship was bombed daily by plane, and eventually was thrown upon the rocks during a severe storm. The repeated calls to general quarters, the fear of sinking, loss of sleep, and continuous responsibility led to deepening depression, and restless sleep. He began to dream of bombing and sinkings, of general quarters alarm, and frequently awakened with a start. There was a recurrence of an anxiety nightmare that he had in childhood. Sharp sounds led to acute anxiety. Following his eventual collapse from the excruciating pain in his back, and the X-ray discovery of the fracture three weeks after the injury, he was evacuated to this country. While aboard the returning transport the patient learned that the men on this ship were not stationed in the magazine in the manner that he had arranged for his crews. The already existing guilt feelings concerning the death of his men were magnified.

The return to this country was first followed by relief, but shortly after his admission to the hospital he again felt tense, fearful, apprehensive, depressed and insomniac, and the nightmares recurred. He was anxious when planes flew overhead or when sirens or whistles were heard, and was unable to attend movies due to his self-identification with the actors. In particular, he plunged himself into the movie "Caught in the Draft," and instead of laughing at this comedy, left, tortured by the fear for the hero who was to be forced into gunfire. He was self-accusatory, declared himself a coward, and expressed a hatred of the sea and the service and all that went with it. Only when at home on leave from the hospital did the patient feel happy and as the day of return approached there was a quick resurgence of the depression. As he failed to improve under treatment and was considered to be suffering a depressive psychosis complicated by his combat experience, he was recommended for prolonged hospital care and eventual retirement by a Board of Medical Survey.

Comment: This commissioned officer had an episode of the manic depressive type four years prior to reporting for active duty and was entering another attack two months before exposure to combat. This second depression, which at its onset consisted of feelings of fatigue and despondence, and short periods of uncontrolled weeping, was aggravated after a horrifying combat experience, and complicated by the characteristic startle reaction to sound and by nightmares. These dreams consisted not only of simple war recapitulations, but also of childhood anxieties. Here the combat-induced emotional disturbance became incorporated in an incipient major psychosis.

It is impossible, of course, to give all of the scores of thousands of cases in the services intensive individual treatment. But both the Army and Navy have come to the conclusion that group psychiatry may be even more effective in the cases of men who have been trained to group discipline. Commander Braceland points out:

"Heretofore psychiatry has been found wanting; it has been wholly dependent upon time-consuming individual treatments, and there were not enough trained psychiatrists to go around. In this war, psychiatry has learned that it cannot concentrate on the individual and permit the group to shift for itself. The Navy has learned perforce that one method of solving it is by group psychotherapy.

"This method, which originally began as an expedient, has been found to be extremely effectual. This should have been evident at once, for as a matter of fact, the patients were originally removed from a civilian group, they were trained and they fought in a military group, and now they live in a hospital group, so it is reasonable to suppose that they should be treated as a group.

"As Rome has stated, 'They pool their collective insecurity and find strength and security in the group.' "

When neuropsychiatrics are discharged from the Services their continued mental health is to some degree the responsibility of their relatives and friends. General Lull points out that they are by no means to be looked upon as being in a hopeless or helpless condition.

"A great many psychoneurotic symptoms are manifested by people in civilian life to a greater or lesser degree," he said. "You are all familiar with the chronic complainer. Nearly everyone has some idiosyncrasy about health. In spite of all this, the psychoneurotic in civilian life is not labeled, nor does he have difficulty in carrying on his business. Some of our most successful political leaders were psychoneurotics."

By the time the N.P.'s are discharged from the armed forces they will have been brought as close to a normal state of mental tranquility as present-day science permits. Wounds of the soul will have been treated with as much sureness and sympathy as wounds of the flesh. The fact that many thousands will return to normal living is in its way as great a triumph as any of the war's great advances in surgery or drugs.

3. Saving The Wounded by Air

In the bright early morning sunshine the winter wind blew in sharp gusts across the Fort Dix airstrip. The landing field was muddy and bumpy with remnants of a recent heavy snowfall. Here and there, the sun glistened in a puddle, casting a reflection that stung the eyes. A line of Army ambulance trucks, red crosses painted on their sides and roofs, was strung out along the dirt road that led to the landing field. Army doctors and nurses stood in little groups, talking casually, but punctuating their conversation with quick, anxious glances into the eastern sky.

Suddenly there was the roar of a multi-motored airplane, heard a good five minutes before it came into sight. The doctors and nurses broke off their conversations, crunched cigarettes under their heels, and climbed into the ambulances. The truck motors were started and everyone on the field became alert with expectancy.

Out of the East came the huge C-54 Skymaster, its wings spread wide. Twice it circled the airstrip and then, with the mincing grace of a circus elephant, it made a perfect landing.

The ambulances rolled out to meet the plane as it taxied to a full stop. The cabin doors were flung open. And one by one litters, bearing wounded American soldiers, were carefully passed through the door and loaded onto the waiting ambulances.

As each ambulance was loaded, it moved away toward the Tilton General Hospital, less than a mile and a half from the airstrip. The trucks picked their way cautiously among the ruts and puddles to avoid disturbing their precious cargo. In a short time the ambulances pulled up before the hospital doors and the litters—23 of them—were carried into a ward that had been especially prepared for them. The wounded soldiers were washed, fed, and their dressings changed. The men were then left to rest and relax. Tomorrow these wounded veterans of some of Europe's bloodiest battles would be examined by the hospital's staff of doctors, specialists in all types of war-inflicted wounds, and the proper courses of treatment and therapy prescribed.

These scenes are part of the operation of a new phase of medicine in modern warfare—evacuation of battle casualties from combat zones by airplane. Actually, the first attempt to remove battle casualties by air was made during the First World War, but these efforts were isolated and met with no special success. It was not until World War Two, fought in almost every section of the globe, that airborne ambulances were utilized to the fullest possible extent. Today, air evacuation of the wounded is a major program of both the Surgeon General's Office and the Army Air Force. In his second report on the Army Air Force activities, made to the Secretary of War in February, 1945, H. H. Arnold, Commanding General of the Air Force, said that since air evacuation began in 1942 "a total of 700,000 sick and wounded men have been evacuated by the Troop Carrier and Air Transport Command. More than 525,000 were flown during 1944. Despite the large number of critically wounded cases evacuated from the fronts, the low death rate in flight of seven per 100,000 patient trips has been maintained, thanks in a good measure to flight nurses and medical flight technicians. Over half of all the patients are Army Ground and Service Forces; almost one third from the Allies; and the remainder are from the Navy, Marines, and the Army Air Forces."

The airborne ambulance is a necessary development in modern warfare, for not only does it aid the casualty by bringing proper medical treatment in the shortest possible time, but it is sound from a military logistic viewpoint. Modern logistics are strongly influenced by the air evacuation service. According to Quartermaster Corps officials, it takes about eight and a half tons of supplies to maintain one soldier overseas for the first thirty days, and one and a half tons for each month thereafter. The personnel of a 750-bed hospital is about 540 persons who, added to the 750 patents and multiplied by the figures in tons per month, create a tremendous problem in non-effectives. The use of the airplane to remove the wounded goes a long way toward solving that problem.

Then, as Lieutenant Colonel Richard Meiling, writing in "Air Force Magazine," points out, the wounded also present a problem to staff officers in the actual fighting zones. The roads in use are limited in size and capacity, and railroads are either not in operation or are of a single track, temporary variety. Since trains and trucks marked with the International Red Cross can be used only to transport patients, the gasoline and oil and other equipment for these vehicles take up vital space in other trucks. Again, since these single-purpose vehicles invariably move in an opposite direction from the flow of general military traffic, the result is congestion and confusion on both roads and railroad sidings.

"Air evacuation is the answer to the staff officer's prayer," Lieutenant Colonel Meiling says. Using the same camouflaged planes that are used to bring troops, supplies, and equipment to the forward lines and which, were it not for evacuation, would return empty, and employing a fighter cover when necessary, casualties can be flown hundreds of miles to the rear of the fighting areas. Hospitals located great distances from the lines present little or no supply and traffic worries for combat unit commanders.

In addition, the greater the number of casualties removed to the United States, the fewer medical facilities are needed overseas; which, in turn, reduces the number of ship-tons of supplies required in the theaters of operations to support these non-effectives.

Both the Allies and the Central Powers employed airplanes to transport wounded in the First World War, but the method proved highly unsatisfactory. Because of the types of planes in use then, the patient was often jammed into the rear cockpit of open planes and flown at comparatively high altitudes. This treatment, of course, did not aid his general condition.

The first ambulance plane is generally credited to a young French physician, Dr. Pierre Chassning, who was also an aviation pioneer. Dr. Chassning, realizing the possibilities of using airborne ambulances in peace as well as war, made a plea before the French Chamber of Deputies in 1917 for funds to finance the development of the airplane ambulance or "ward on wings," as he called it. In addition to being a doctor and an aviation enthusiast, Chassning was also an astute politician. He represented the Puy-de-Dome district in the Chamber, and when his plea met with ridicule and criticism, he applied political pressure. By the end of 1917 he had obtained the necessary funds and the first military airplane ambulance was built. The first flight occurred at Villa Coublay, with Dr. Chassning demonstrating its practicability by serving as the first patient. The "ward on wings" saw service on the Amiens front and is credited with saving many lives.

In the meantime, in this country, Major Wilson E. Driver, a reserve officer in the Army Air Corps, and Captain William Ocker, Army Air Corps, were working in collaboration in the designing of the first American ambulance plane. Numbered 3131 in the Army service, the aircraft was placed on active duty September, 1918, at Gerstner Field, Lake Charles, Louisiana. Actually, the plane was a reconverted Jenny, with the rear cockpit rebuilt to accommodate a primitive type of litter.

In the next year, American air officers and medical men, seeing the possibilities of such a plane, worked hard to perfect patient accommodations in the aircraft. Flight surgeons urged the use of the air ambulance and, generally speaking, the transportation of patients from airfields to general hospitals by air was encouraged. However, historians of this development of air activity say that there was much opposition among some military officials to air evacuation as such.

While the bickering was going on in this country, the French again took the lead in air ambulance development. Major Renee Epaulard, in October, 1921, organized the world's first airplane ambulance squadron. It consisted of six planes designed to carry two or three litter patients each. This organization saw extensive duty in Morocco in 1921 and 1922. It is estimated that about 700 members of the Foreign Legion were evacuated by air during the last six months of 1921.

The U. S. Marines in Nicaragua in the nineteen-twenties soon discovered that evacuation by air was the answer to their casualty problem and it also reduced the ambush hazards for litter parties moving through the jungles to the rear.

Today, the organized air evacuation service of the Army Air Forces depends mainly on two types of cargo and transport planes—the C-54 and C-47. These are the same planes that carry jeeps, field artillery pieces, paratroopers, gasoline, oil, food and other supplies to the forward fighting areas. On their return from the fighting zones—whether it be within the various theaters of operations or between the theaters and the United States—these planes fly hundreds of casualties. In some instances PBY amphibian planes have been used, and L-1's and L-5's under circumstances we will describe later; but generally the AAF truck horse, the C-54, carries the wounded evacuation load.

The way the air evacuation units operate is as simple as it is dramatic, according to Major Jeremiah Shea, the U. S. Air Forces Public Relations Officer at Fort Dix. While no "commuter's service" is maintained on the planes, Major Shea said they cross the Atlantic and Pacific with amazing regularity. Men are designated at the base hospitals in France or England to make the trip, they are taken to the field where the plane is standing by, the litters are loaded, and then the "ward on wings" zooms into the sky and heads for home.

The selection of cases to be flown back to the United

States is left entirely to the discretion of the medical officer in charge of the base hospital, who acts under a broad directive from the Surgeon General's office. Generally speaking, cases which need special care, therapy or surgical attention form the bulk of the evacuees. Ambulatory cases which require a prolonged convalescence are also flown back to reduce the supply needs and for the mental lift the patients will receive by being back home.

The planes are loaded in the combat zones and flown to the airfield in this country that is nearest to a hospital equipped to handle the returned wounded. Often, however, an ambulance plane whose original destination was Mitchell Field, near Halloran General Hospital, might be rerouted because of weather conditions or other circumstances. The hospitals are always ready to receive the patients, since they are notified in ample time to prepare for the plane's arrival.

Once the plane is landed in the country, the wounded soldiers do not stay at the initial hospital. After a few days of rest and necessary treatment, they are again placed in airplanes and flown to the Army general hospital nearest their homes. The purpose of this transfer is twofold: first, the wounded veteran benefits in morale when he is near home, especially if he is faced with a long convalescent period; secondly, since the first impulse of friends and relatives is to rush to the wounded man's side, it relieves the strain on transportation facilities to have the patient nearby. Of course, where a man's wounds require special care and attention, or he attempts an unusual rehabilitation program calling for expert instruction and guidance, he is hospitalized at the institution best for this purpose.

It is explained that while most of the huge C-54's are capable of flying from the combat zones, clear across the Atlantic—or Pacific—and then flying on to hospitals located in the far South or Mid-West on non-stop trips, the plan is not economically sound. The C-54 unloads its cargo at the first airbase and general hospital, and then prepares for the trip back. The smaller C-47's are used for the transcontinent flight. The large amount of gasoline necessary to fly the huge airborne hospital wards across the Atlantic and then halfway across the United States non-stop would, through necessity, reduce the number of patients the flight could accommodate since wounded men would have to be sacrificed for fuel supply. However, when a plane is loaded with a group of wounded men who, in all likelikehood, will eventually end up in the same hospital, since they all come from the same general geographic district, it is then practical and economical to make the trip from combat area to hospital in one flight.

In Africa, Alaska, New Guinea, Sicily and on the Western Front, hospital planes, in addition to moving battle casualties, have been called upon to move field hospitals and their equipment hundreds of miles. In one instance related in "Air Force Magazine," ten planes were used for the operation and, in another, forty planes. Perhaps the most remarkable feature of these transfers is that the hospitals were set up, ready to receive patients at their new location on the same day they were flown forward.

In May, 1942, the first airplane ambulance battalion was formed at Fort Benning, Georgia. It was transferred to Bowman Field, Kentucky, in October, 1942, and there designated as the Army's first Air Evacuation Group. But further reorganization was necessary to get a smooth-working evacuation unit and the Medical Air Evacuation Transport Squadrons appeared. Toward the end of 1942, on the most appropriate day of the year, Christmas, the first Air Evacuation Squadron zoomed away from Bowman Field for the North African front. This flight was soon followed by other squadrons into far-flung battle areas until today the Air Evacuation groups are serving American casualties in every war theater throughout the world.

But all air evacuations of wounded men have not been carried out by the super deluxe ambulance airliners. Some of the most dramatic rescues of wounded soldiers were performed by tiny two-place "L-4" planes that putt-putted along at the heartbreaking speed of 70 miles an hour over the Japanese-infested Burma jungles. These planes form a comparatively new addition to the Army Air Corps. Going into action in the spring of 1943, their official mission was to provide theater and task force headquarters and ground force units with general liaison messenger and courier service in areas behind the front lines of the enemy's troops. Actually, however, the squadrons performed functions in combat theaters that will never be found on any official activation chart.

For example, in Burma, during the first days of the liaison squadrons, two separate light plane units were operated. One was attached to the 10th Air Force, based at Ledo, India. It supported the Chinese-American forces in that district, including the famed Merrill Marauders. The second unit if the light planes was part of the Air Commandos under the command of Colonel Philip Cochran and Colonel John Alison. Cochran has been made famous by the parallel character, "Flip Corkin," in the popular syndicated comic strip, "Terry and the Pirates." This group is believed to be the first to use a small type plane in the evacuation of a large number of casualties.

But even before the Commando operations were activated, the liaison planes went into action in response to a desperate call for help from the British troops fighting in South Burma. Trapped in the Arakan area, a large British Army unit was in immediate danger of being wiped out. Many hundreds of British Tommies had been wounded and there was no way of bringing them out of the jungles to safety and medical treatment. Seven light planes, operated by Yank sergeants with pilots' wings, were assigned the difficult task of aiding in the removal of the casualties. The hazards of the flight were great, since the Japanese had almost complete air superiority in the section, and their ground troops were able to supply a heavy ack-ack barrage.

The British Army considered the removal of the wounded so important that it provided a heavy Spitfire cover for the small, light planes on their errand of mercy. In fifteen days, these planes, landing on postage stamp clearings and able to pick up only one or two wounded men at a time, evacuated more than 700 casualties to field hospitals. In later operations, however, no fighter umbrella was provided, and the liaison planes ran the risk of enemy planes and ground firepower in evacuating the wounded to places where they could receive medical care.

Fighting in the Burma jungles at that time was extremely hazardous. Japanese machine gunners and snipers lurked behind almost every brush, shrub and tree. And even if the British had been able to overcome the enemy, the ground forces would have required weeks to move the wounded through the dense jungle forests. The little liaison planes made the trips in a couple of hours.

Exact figures are not available on the light planes' mercy flights, but Major General George Stratemyer, commanding general of the Eastern Air Command, estimates the planes flew 5,000 to 8,000 sorties during the commando operations and that they evacuated more than 2,000 casualties.

These planes are of three types—"L-1," "L-4" and "L-5." The "L" designation indicates liaison. The "L-1" and "L-5" carry two men each, but in removing the wounded from the field of battle, it is common for the "L-5" to take three men and the "L-1" four passengers, in addition to the regular two-man crews. Colonel John Alison, who shares command of the Air Commando group with Colonel Cochran, said in a report on a certain operation, "There was no other way to get the wounded out. They needed medical attention and we tried to make sure they would get it. There was some degree of crowding necessary to get the injured in these small airplanes. But the men seemed very glad to sacrifice comfort for safety and speedy medical care. A wounded man behind the enemy lines is a worried man. The knowledge that the light planes were risking dog fights with the enemy and ground gunfire to evacuate the wounded was a great help to general morale. Those planes came into postage stamp fields of 500 feet or less. They would take on two or three casualties. You would stand by and look at the heavily loaded plane as it taxied into the wind for a takeoff . . . and you would wonder how in hell they thought they could do it. But the next thing, the plane would be in the air, puffing and chugging toward the nearest place of safety for the wounded. There was jungle on all sides of these tiny airstrips and, unfortunately, we did lose a couple of planes when they crashed into tree tops on takeoffs. But these accidents were very, very few. Because these fields were so small, only a few planes could come in at one time, so we ran a regular shuttle schedule with some planes making two to four trips a day with wounded men for the behind-the-line hospitals."

Of course, operations of the light plane type are, in these days of the war, the exception, and are used only in battle areas where it is impracticable to use the big C-54's, which, in addition to being more comfortable for the wounded passengers, have the added advantage of providing adequate medical attention while in flight.

The personnel of the Medical Air Evacuation Squadrons is one of the principal reasons for its success. Its men are carefully selected for their training in the AAF School of Air Evacuation at Bowman Field. The applicant for assignment with the squadrons, whether it be physician, flight nurse, or hospital corpsman, must pass the physical examination required of all flying personnel, and he must be recommended as being particularly adapted for air evacuation activities. These requirements, naturally, make for an exceedingly small group. From this number a selected few enter the school about every two months. On admission to the course at Bowman Field, the applicants are again examined by flight surgeons before being permitted, finally, to start the initial steps of their training.

The course is exceptionally difficult and strenuous. Doctors, nurses and accepted enlisted personnel must study selected phases of aerial medicine, aeronautics, tropical medicine, intravenous therapy, field sanitation, field service, compass, map and aerial photography orientation, defense against air and gas attacks, and other military and medical topics.

Upon graduation, the students are assigned either to an Air Evacuation Transport Command or to a hospital while awaiting activation of a new unit, or assignment as a replacement for personnel already serving overseas with an evacuation unit. These graduates are in constant demand.

A study of operation methods and procedures of these Medical Air Evacuation Transport Squadrons may indicate, in a small degree, the tremendous job they are doing. The headquarters and headquarters section of the command has one flight surgeon, who serves as commanding officer, one flight nurse, who is given the duties of chief nurse, and one administrative officer, who is in charge of the non-medical departments of the command, such as supply, transportation, and mess.

In addition, there are about 32 enlisted men who serve as clerks, cooks, and drivers. Usually, there are four flights under the command of this headquarters or headquarters section. Each of these flights is commanded by a flight surgeon, and composed, in addition, of six nurses, six surgical technicians and two clerks. Each flight is divided into six evacuation terms of one nurse and one soldier.

While a general pattern of evacuation is laid down by both medical and Air Force officials, the evacuation teams must be permitted to operate with flexibility in order to meet the immediate problem with which they are confronted. The usual method of air evacuation within a battle zone is to send one flight surgeon forward into the combat area. There he coordinates with the ground medical installations in selecting the wounded to be evacuated, and maintaining at all times liaison with the flight operations officer of his airfield. In this way a near-perfect timing is set up. He is able to arrange for patients to arrive at a landing strip about the same time the ambulance plane comes in and is available for loading. It can be easily understood that it is better for their safety and comfort if they do not arrive at the airstrip until the plane is about ready to come in and take on passengers. The actual loading of casualties by the skilled air evacuation teams is only a matter of minutes. This same type of coordination is in effect at the base hospital in the rear or, if the ambulance plane is flying direct to the United States, at the landing fields here. The ambulances are lined up at the field when the plane comes down and the patients are removed to the hospitals as quickly as possible. There is no waiting for transportation.

Aboard these cargo or transport planes, litter supports are available. Frequently they consist of metal racks, in which case, as with the C-47, the plane can carry about eighteen patients. Sometimes parachute webbing straps are used and here the C-47 can carry twenty-four litter patients. Naturally, it is not always desirable to load the plane with litter cases only. When the passenger list of the air ambulance has both litter and ambulatory cases, the "sitting and walking cases" are made comfortable for the trip by using the bucket seats used by paratroops and other airborne soldiers in their movements to forward areas.

When one of the huge transport or cargo planes moves forward carrying supplies, equipment and personnel, the flight evacuation team of one medical flight technician and one flight nurse move up with the plane. On arrival they immediately set to work to convert the plane to receive the wounded and to supervise their loading. Often, when the fighting has been hard and the situation tense, the flight evacuation team has jumped in and helped load the plane, too. The flight surgeon at the forward airstrip keeps a complete record of all patients evacuated, and the flight nurse aboard the plane maintains a complete, accurate chart on each man's record, including diagnosis, time in the air, altitude at which flown and treatment required in flight. Each evacuation team has available aboard the plane a kit labeled "Chest—Airplane Ambulance." This medical chest contains necessary equipment such as heating pads, bedpans, syringes, as well as medicaments, blood plasma and food required en route. In addition to the flight nurse and medical flight technician, a regular Army physician accompanies the plane on all flights of any great distance. These doctors are not flight surgeons, since that title is reserved for physicians concerned with the medical problems of flying and flight personnel. Since most of the wounded being evacuated are ground troops, their injuries are given care and attention by a regular physician. One flight nurse at Fort Dix compared the trans-oceanic flight to a "ward on wings" with herself and the doctor making the flight as the "resident physician" and "nurse on duty." Any account of the air evacuation activities which omits mention of the heroism and devotion of the Army flight nurse has missed one of the most thrilling and dramatic highlights of the evacuation operation. For these women are a group apart. On duty, they forsake the traditional Army khaki and wear dark blue uniforms. On their breast they wear the Army's flight wings with the medical caduceus superimposed and the letter "N." These women were at Bougainville, at Siciliy, at Salerno, at Anzio, on the Normandy beaches, and at Leyte and Luzon. Name any big push and the boys who were there will tell you the Army's flight nurses, moving with calm efficiency and women's tenderness, were on the scene a few hours after the troops dug in, caring for the wounded and getting them to safety and medical treatment as quickly as possible. They were the first white women on Munda, Guadalcanal and other South Pacific islands since the war began; they were the first U. S. Army nurses ever to reach China.

Like many serving in today's Armed Forces, they get around the globe, but that is only part of their story. Too often they have had to pay a price for choosing this type of duty—the soldier's price—death from enemy gunfire. Recently thirteen flight nurses were in a plane shot down over enemy territory. They landed safely and spent months escaping. Others have had to "hit the silk" to save their lives and many have had brushes with the enemy—"too damn close for comfort," some say. Nurses flying the South Pacific route have often arrived to find the field "Condition Red," i.e., "stay away—enemy here." Others have spent long hours in foxholes biding their time to load the air ambulances safely. One flight nurse on Guadalcanal experienced fifteen air raids in five and one half hours before her plane could take off. Men who were in the Southwest Pacific theater say they could add a few chapters of their own about the valor of these women. They saw the flight nurses put up with everything they had to face—scorching suns, torrential rains, swarms of mosquitoes, the presence of malaria, dengue fever, inadequate quarters, and eating food out of mess kits while standing ankle-deep in mud. There were no quarters for them at Guadalcanal at first, so the overnight stop on the long trip from New Caledonian headquarters was generally Espiritu Santo. Up at 0100, takeoff at 0300, arrival at Henderson Field at 0730 to pick up the battle casualties sent down from the fierce fighting up at New Britain. When the plane landed, a jeep would dash out with sandwiches and thick, black GI coffee to be gulped while swatting mosquitoes and chasing flies. In fact, K-rations, eaten while in flight, often constituted the only semblance of a meal these girls had in days.

Flight nurses are real people, not given to many pretenses. Of course, they get their share of attention wherever they go, but they say this is only because they are symbols, that they serve to remind the men of the wife or sweetheart they left behind. And, on occasion, they are frank enough to admit this can be annoying. Often the nurses' dates take on an aspect more practical than romantic. Nurses can afford to be independent—and they admit it. Flight nurses, especially overseas, accept invitations with considerable foresight and judgment. But they tell the story of a GI in the Pacific who had a flat iron—and that iron got him more attention from females than a penthouse full of etchings ever would.

"We would go on ironing dates," one of the nurses explained. "Keeping our clothes neat was our toughest problem at first. We had water three times a day—for a couple of minutes each time—and that was all. But we could always wash our clothes in the river; however, we couldn't iron them since we had no electricity at that time. The fellows had rigged up some kind of a dynamo, though, and one boy had an iron, so we'd take our clothes over to their section and spend a nice, domestic evening at the ironing board and listen to the boys tells us how they scored the winning touchdown back on the hometown football team. Sure, it was funny . . . but it was kind of nice, too."

Lieutenant Henrietta Richardson, an Army flight nurse for the past four years, writes in the AAF magazine "Air Force" that 132 hours of combat evacuation flying in North Africa convinced her that "the presence of a nurse on duty in actual flight is sometimes just as important to our wounded men as her attention to their physical comforts in a hospital."

In recounting her experiences, Lieutenant Richardson says: "During the two months I served with our Evacuation Squadron as flight nurse in North Africa, we flew one evacuation mission a day, sometimes totalling 87 hours a month. My principal job was to see that the wounded men—usually about eighteen of them—were made as comfortable as possible during the flight from the combat zone to the base hospital. This meant giving medication and hypodermics to ease pain, reinforcing bandages, administering oxygen and blood plasma when needed, or just handing out rations to patients who felt well enough to be hungry.

"But in those planes, thousands of feet above the earth, I found the nurse can have a definite morale effect on the men, and therein, perhaps, lies the hardest part of our jobs. Each patient requires individual attention. Many of them are seriously wounded and are suffering from those first few hours or days of shock. They have not yet had time to realize, much less adjust themselves to their handicaps. In most cases this state of extreme sensitivity calls for all the tact and understanding a flight nurse can give them.

"One of the boys may be bursting to tell you how he had his leg shot off. Just telling his story to someone who will listen seems to have a real therapeutic value. He gets it off his chest, every little detail, and he seems to feel better. On the other hand, on the same plane, you may have another patient who doesn't even want you to mention his wounds or how he got them. He just won't discuss them—or anything else. So you learn when to try to cheer people and when to just shut up."

But there is one thing you cannot get a flight nurse to admit—that there is anything heroic or even difficult about her job. In the first place, she tells you there isn't time to think about herself. And on evacuation missions this is literally true. Looking after 24 men whose care has been entirely entrusted to one woman is a full-time job. It doesn't permit much thought of the comforts left behind.

Always her patients come first. It's up to the nurse to care for them, make them comfortable and see that they arrive at their destination in as good a physical condition as expert nursing can assure them. And where war air travel is concerned this means being prepared for almost any emergency, being ready to cope with the unexpected. Several months ago, the plane on which Lieutenant Dorothy Shikoski was flight nurse was forced down at sea. In the crash, Nurse Shikoski's back was severely injured. Yet, with no thought of her own safety, she helped her patients into life rafts, cared for their wounds as far as was possible under the conditions, and attended them constantly until rescuers arrived.

Once the evacuation plane is airborne, the cabin becomes a "ward on wings" with the nurse in charge. "Routine nursing care," it is called on the official charts, but any wounded soldier who has been evacuated knows that it is more than just watching symptoms, changing dressings, giving plasma or bringing out the morphine syrette when she sees fists clenched in silent pain. It's more than adjusting a splint on a leg or asking the pilot to descend slowly so that a too-sudden air pressure change won't make a man's chest injury worse.

Maybe it's a lot of little things. Or it could be her smile, her calm efficiency and the way she keeps everything under control. Battle-hardened soldiers are amazed at these airborne nurses, how they keep up the hard, tiresome flights, month after month in all parts of the globe. A patient can forget some part of his own troubles in admiration for the girl aboard his plane—and the hundreds of other just like her who have made the Army's air evacuation program such a tremendous success. Call it "routine nursing care," call it, as Lieutenant Richardson does, "morale building," call it anything you like—the flight nurse's sincere desire to help and comfort her patients, her warm spirit and friendly disposition have won for her the same high accolade on every battle front where American soldiers are fighting.

4. Ice Therapy

A NAVY DESTROYER on patrol duty somewhere in the South Pacific crossed the path of a lone Japanese aircraft carrier. It radioed the carriers with the American task force operating in the area and then attempted to engage the Nipponese ship alone. Fliers swooped down on the courageous little destroyer and dropped their loads of death on the decks from bow to stern. But the enemy's fliers were a little off the target. They did not sink the doughty ship and, eventually, were forced to abandon their attempts in order to escape the armada of U. S. fliers which came roaring out of the clouds to join the battle. According to Navy reports, the Japanese carrier was sent to the bottom. The American destroyer was still afloat, but it had sustained severe damage and many of its personnel had been injured in the melee.

In 24 hours, it limped alongside the hospital ship, *Solace,* on duty in the area, and surrendered its wounded to the professional care of the doctors and nurses on the ship's staff.

One seaman transferred to the *Solace* was reported in a critical condition. A Japanese bomb fragment had torn through his right thigh. He was suffering from severe shock and a great loss of blood. Navy physicians indicated that an immediate amputation was necessary. It was, perhaps, his only chance to survive. But his general condition was so poor that the doctors feared he might never recover from the operation.

So, the Navy surgeons applied a small tourniquet, made of rubber tubing, above the wound, sprinkled the injured area with sulfa powder, and then bandaged it loosely with vaseline gauze. Finally, the entire leg was placed in an insulated cabinet. This cabinet was attached to the Freon cooling unit in the ship's drinking fountain and, with the refrigeration thus obtained, the leg was chilled to just above the freezing point.

The wounded leg responded to the ice treatment in an amazing fashion. First the patient reported that almost all pain disappeared. Then the leg lost its cyanosis, or blue appearance, due to insufficiently circulated blood. And, perhaps most important of all, all infection growing from the wound was definitely checked. At this point in the treatment, the doctors began to give the sailor whole blood and plasma transfusions. His strength increased and, after his leg had been in the refrigerated cabinet for 29 days, the Navy surgeons decided the seaman would be able to undergo an amputation. The operation was performed and the sailor recovered from an amputation which, if it had been attempted when he was first taken aboard the hospital ship, would, in the opinion of the surgeons, have proven fatal.

The report of this case of crymotherapy, or the therapeutic use of cold, was made in a recent paper published in the "Naval Medical Bulletin." The authors, Lieutenant Commander John P. Ottoway and Lieutenant John J. Foote, both of the United States Navy Medical Corps, point out that while ice and cold applications have been used as therapeutic agents since the days of Hippocrates, it was not until World War II that the technique of crymotherapy reached its highest level. After Hippocrates, the medicine men of the Arab tribes, roaming the scorching desert sands, recommended the use of cold treatments for many of the diseases then known. It is said that Napoleon's surgeons, during the retreat from Moscow, reported the intense cold of the Russian plains made amputations almost painless. During the past century cold brine solutions were used to minimize pain and suffering. Today the use of "refrigeration anesthesia" is, according to Captain C. M. Shaar, Medical Corps, U. S. Navy, an "important contribution to surgery" and "its usefulness in the future will probably extend to include any type of major amputation." A Navy surgeon, Captain George W. Calver, writing in the Navy Medical Bulletin, says that "the use of ice packs (in war-inflicted wounds) has permitted the salvaging of limbs that formerly would have been amputated."

What is the story behind the present enthusiasm of medical men for refrigerated anesthesia? Cold applications have, as we said, been recognized as therapeutic agents for centuries. But the applications were, at the best, haphazard and primitive. Who and what is responsible for the development of this "important contribution to surgery"? What brought about the evolution of cold surgery from carbon dioxide snow to the present mechanically controlled anesthesia apparatus?

There are two answers to these questions. The first is the most obvious: the medical men, ever searching for new formulas to cure old ills and perfect outmoded techniques, are responsible for much in the present crymotherapy technique. The second factor in its development is World War Two—a war in which the number of amputations up to January, 1945, exceeded all similar operations in the First World War by more than two thousand. While the use of cold surgery may be traced back to the early Greek civilization, real progress in crymotherapy had to wait until the twentieth century: had to wait, in fact, until the United States was on the threshold of the most inhumane war in all history.

In 1938, at the Temple University Hospital, in Philadelphia, Dr. Temple Fay and his colleagues reported astounding results in the treatment of malignancy and infection by local and general refrigeration. These modern pioneers in cold surgery worked for more than a year on refrigeration anesthesia, or "frozen sleep," as they called it, before making public a report on their experiments. The Fay report said that the use of frozen sleep showed a considerable reduction of pain in many inoperable cases and definite clinical improvement. It stated that "refrigeration" caused the malignant growth to shrink in size, in many instances causing the disappearance of local tumors without any unfavorable effect on the surrounding tissues.

In New York, Dr. Frederick Allen, a diabetes specialist, was also experimenting with the modern possibilities of refrigerated anesthesia. He had used a primitive type of refrigeration on his patients with some success. He believed that it might be developed, and applied a great deal of his time toward perfecting a "cold sleep" technique. One of the principal complications in diabetes cases is the victim's susceptibility to a type of progressive infection that attacks the toes and feet, called gangrene. Gangrene decay is difficult to check and in many cases amputation becomes necessary.

Dr. Allen's experiments took the form of applying tourniquets to the tails and limbs of laboratory animals and then producing gangrene by artificial methods. He found the tissues in the constricted areas rotted quickly at room temperatures, but when cold was applied, Dr. Allen discovered that not only did the tissues in the blocked off zones survive longer, but that there was a marked resistance to shock, infection and injury to blood vessels and nerves.

Dr. Allen's experiments and success with the refrigeration anesthesia was given some publicity in New York medical circles and, as a result, Dr. Lyman Weeks Crossman, a surgeon attached to the staff of the New York City Hospital, began tests with cold surgery in relation to diabetes and arthritis cases who were scheduled to undergo amputations for gangrene. Dr. Crossman's report showed that the use of ice reduced the mortality rate for this type of operation to an amazingly low percentage. At the New York City Hospital, the mortality rate for gangrene amputations ranged from 55 per cent to 80 per cent, with the chief causes being shock and infection. But with the inauguration of the refrigeration anesthesia by Dr. Crossman, the death rate fell to a new all-time low. In a selected group of 154 patients, whose average age was 68 years—several patients were more than 80 years old—successful amputations were performed on all but seven.

The Navy Department's three "ice" specialists, Captain Shaar, Lieutenant Commander D. T. Jones, and Lieutenant Commander T. R. Lehan, say that the war has streamlined the "cold surgery" technique. While Dr. Crossman's method of refrigeration was, for surgical circles, a simple process, the Navy has reported additional refinements and the elimination of unnecessary discomfort for the patient.

In his "Surgical Clinics" paper for December, 1944, Captain Shaar advises surgeons that good results from refrigerated anesthesia can be obtained by following his small manual of technique. A small rubber tubing tourniquet is applied just above the operative zone after that area has been chilled for about an hour. This pre-chilling at the operative level is designed to reduce pain and discomfort before the tourniquet is applied. When the rubber tubing is tightened enough to stop circulation, and secured from slipping, refrigeration is immediately begun. The limb is packed in cracked ice to at least four inches. Captain Shaar is emphatic in saying that cracked ice should be given the preference as the chilling agent. Dry ice, carbon dioxide snow or salt in ice should never be used, he says. Any one of these agents may cause destruction of the tissues by freezing. A skin temperature, determined by placing an ordinary thermometer against the limb, maintained at about eight to ten degrees centigrade is "very satisfactory."

Dr. Robert Mock, a Boston surgeon, thinks that a drink of whiskey at the start of refrigeration, and repeated, if necessary, is a "good treatment." It allays the patient's pain and apprehension and often makes the use of opiates unnecessary.

About three hours of refrigeration are required in the average amputation case. However, it has been noted that when a patient's condition is critical, refrigeration for six hours may be required, but with the prolonged chilling the general condition improves and, in some cases, Captain

Shaar says, the improvement "is spectacular."

One of the unusual developments in ice surgery came, not from physicians and surgeons, but from the crew of a badly damaged aircraft carrier. Here is the story the Navy officials tell of a pre-operative technique developed by the machinists and tinsmiths of the carrier:

The ship had been part of a task force supporting the invasion of Leyte. A few Japanese fighters and bombers did get into the air in a futile effort to stave off the General MacArthur landing, and one Nipponese fighter came swooping down on the flight deck with its machine guns squirting death for those crew members who were unable to get cover in time. A stream of shells ripped through an aviation machinist's leg, shattering the bone at the calf of the leg. The man was taken below and plasma administered. As soon as possible he was transferred to a hospital ship, but here his treatment ran into difficulty. The Navy surgeons knew an amputation was necessary and that ice surgery was about the only way it could be performed successfully. However, the hospital's supply of cracked ice was running low, and because of some mechanical breakdown, the cooling unit was not functioning properly to provide refrigeration for an operative case.

So, the carrier's crew, standing by for the transfer of other wounded, designed a metal box encased in a wooden frame allowing an opening at one end for water drainage. This box helped conserve the dwindling ice supply and kept the leg at the proper temperature. According to Navy doctors, it proved more satisfactory than the packs used previously. A similar box, but cooled by mechanical means, is in general use now. Surgeons point out that the mechanical cold has the advantage of maintaining a controlled temperature and the disadvantage of requiring expensive apparatus. Ice is not usually removed until the patient is in the operation theater and the anesthesia thus obtained lasts for about 60 to 75 minutes.

The ice anesthesia is just about as complete as a pain "blackout" can be. The patient feels nothing, not even when the nerves are severed and the bones sawed. With the nerves in an almost frigid state, the tissues cannot transmit pain impulses.

The post-operative condition of the patient does not vary too much from that of others where another type anesthesia has been used. Healing is somewhat slower than in ordinary operations, but the progress steady. However, the patient's contact with cold still continues. The stump is surrounded with ice to minimize post-operative pain and swellings. And in a comparatively short time the patient is sufficiently recovered to be willing to discuss the simple technique of how he lost his leg.

The military medicine periodicals are constantly reporting cases where men suffering from war-inflicted wounds have been saved through the use of ice anesthesia. One issue of the "Surgical Clinic" tells of a soldier who was admitted to a field hospital after his right leg was crushed by a bumper on a jeep. The diagnoses said all the blood supply in the poplieal area had been destroyed. The soldier complained of intense pain in the knee and loss of sensation in the right calf and foot. The examination showed the calf and foot to be pulseless and there was evidence of gangrene and early infection. After refrigeration anesthesia was applied for a five-hour period, a guillotine amputation was performed in the lower thigh. The rapid pulse and high temperature subsided and the patient had an uneventful convalescence. On his return to this country, it was unnecessary for him to take any treatment in the

Army hospitals here other than to take a short course in occupational therapy to adjust himself to his physical handicap.

This operation was performed only a short distance from the front lines, and during the pre-operative chilling period, the area was under heavy air bombardment from enemy fliers. It is believed that were it not for the surgeon's quick action and the use of ice, the injury would have been fatal.

The medical journals list many cases where ice therapy has been instrumental in relieving the pain and suffering of patients desperately ill, who must undergo amputations.

Perhaps one of the best examples of refrigeration anesthesia and how it helped a patient is cited in Captain Shaar's paper. A fifty-six-year-old veteran of World War One was admitted to the hospital complaining of pain and ulceration of the right foot and leg. He gave a history of having been treated for several years for diabetes and arteriosclerosis. He appeared to be desperately ill with a temperature of 104 degrees and a pulse of 140. Examination revealed advanced arteriosclerosis and diabetes with gangrene of right foot and leg, and a rapidly spreading infection. Refrigeration anesthesia for a period of four hours which was followed by low right thigh amputation brought remarkable results. The veteran's immediate postoperative condition was excellent and convalescence was uneventful. The patient was permitted out of bed in a wheel chair the second day after the operation.

Another case reported by Captain Shaar told of a 47-year-old veteran admitted to the Naval Hospital with well advanced gangrene involving the right foot and distal third of the right leg. The patient stated that six years previously he developed phlebitis in both legs which later was associated with ulcers. Since that time the ulcers showed some improvement, but never completely healed. The patient appeared severely ill, with rapid pulse and a temperature of 102 degrees. Examination of the right leg and foot showed spreading gangrene and a cardiac examination revealed evidence of well advanced coronary heart disease. Three and a half hours after refrigeration anesthesia was begun, a modified Callander amputation was performed on the lower right thigh. The patient was placed in a wheel chair on the second day following the operation and the convalescent period was uneventful.

However, ice surgery is not a "cure all," and while its percentage of success is exceptionally high, hospital records show that occasionally the patient fails to respond to the cold therapy. Such a case is reported in "Surgical Clinics," December, 1944. A veteran was admitted to the Naval Hospital in a moribund state. Gangrene had infected the left foot and was rapidly spreading over the leg. The man had previously visited a chiropodist and developed an infection in the left large toe. Attempts to control the patient's diabetes failed. The ex-soldier appeared dangerously ill with a high temperature and extremely rapid pulse. Ice anesthesia applied to the left extremity showed only slight clinical improvement, but an operation was necessary. The patient died 24 hours after the operation from congestive heart failure and complications.

Another operation, using refrigeration, was performed on a veteran admitted to the Naval Hospital on September 11, 1944. This man complained of a severe pain in the left leg for the past few days. He had been a known diabetic for several years and had been on insulin therapy which he discontinued about four months before seeking admission to the hospital as a veteran of the First

World War. The man's heart was slightly enlarged and his liver condition generally poor. The left leg was pale and cold to the mid-thigh. No pulsations were palpable in the left leg and only the femoral pulse was present in the right. Parasympathetic blocks were made of the left lumbar region and this action gave the patient some slight relief from pain. However, no appreciable change was noted in color or temperature of the left leg. After four hours' refrigeration, a mid-thigh guillotine operation was performed successfully. As a post-operative measure, the stump was packed with ice to reduce swelling and a skin traction applied. The report says the convalescence was uneventful and, after a reasonable period, the patient was discharged.

Captain Shaar closes his history of typical cases where refrigeration anesthesia was used by reporting a final amputation which was successful because of refrigeration. Complaining of pain, ulceration and gangrene in the left foot, a veteran of the Belleau Wood battle was admitted to the hospital for treatment. During a period of observation, the condition grew worse. Examination of the left foot showed an extensive gangrenous process, involving the great, second, and third toes and dorsum of the foot with diffuse purulent drainage from the ulcer area. An amputation was indicated and, after four hours' ice anesthesia, was performed successfully. Again, the report says convalescence was progressive and uneventful.

The future of refrigeration anesthesia is even brighter than its present career. Doctors now engaged in military medicine are making notes on how it can be used to improve operative techniques when peace is restored. And at least one doctor sees a new path cold applications may take when he is free to experiment.

That doctor is Lieutenant Commander A. Duane Beam, Ophthalmologist-In-Charge at the Naval Hospital in Philadelphia. Dr. Beam, who was a prominent eye specialist in Detroit before entering the service, said recently that he was working on a way to use cold applications in the killing of bacteria that often lodge in delicate sections of the optical nerves.

"Frankly, there is no way refrigeration anesthesia can be used in eye operations," Dr. Beam said, "but there are other ways it can be utilized. Some of the most serious eye infections are rooted behind the eye ball and now, the only way we can get to them is to remove the eye. But cold stops the growth of bacteria. And, if we can work out some way of chilling the eye to kill those germs, the whole technique of eye treatment will be revolutionized."

Dr. Beam is now working on a small mesh cup, made up of many strands of copper wire, that would fit over the eye and serve as a cold conductor. The progress on experiments has been slow, so far, because of the more pressing problem of meeting the needs of returning veterans, but he hopes to reach the point shortly when he can try his device on laboratory animals.

Other doctors, now engaged in war medicine, are equally enthusiastic about ice therapy, the ancient treatment that required a bloody war to win prominence. The entire medical profession appears to join in the prophecy of Captain Shaar that "its usefulness in the future will probably extend to include any type of major amputation."

5. Treatment of War Burns

THE HORRIBLE fire which swept through a Boston night club, the Coconut Grove, in November, 1942, and which cost the lives of 500 people, gave medical men their first opportunity to test a new type of burn treatment on a large scale. That disaster, horrible as it was, developed into a proving ground for a treatment that has saved the lives of many men suffering from war-inflicted burns and scalds. The Coconut Grove fire offered civilian physicians their first "on the field" chance to test the pressure bandage technique in treatment of burns, a technique that required no complex compounds or ointments, but merely a handful of common mechanics' waste, the type every machine shop uses to wipe grease from hands and tools.

Working rapidly on those victims of the fire who could still be saved, the doctors sprinkled the burns with sulfa drugs, and then placed the sterilized cotton waste over the burned area. The results were amazing. Cotton waste, said the doctors, reporting the treatment of the fire victims in

"Surgical Clinics" of June, 1943, was instrumental in keeping the Coconut Grove death toll from being even greater.

The pressure bandage technique, applied with such great success at the Boston fire, has gone on to even greater success in World War Two. For this is a "gasoline war" and vehicles on the land, in the air, and on the sea are using that and other inflammable fluids in unprecedented quantities. Because of this, the dangers of severe and painful burns are increased a hundredfold. According to Navy doctors, one out of every four war casualties suffers burns. Of those men injured in the December 7th sneak attack on Pearl Harbor, it is estimated that 60 per cent were burned. And before the landings at Casablanca in the North African campaign were successful, 400 men had been burned in torpedoings.

Flaming oil and gasoline on the ship and on the water are not the only causes of burns in warfare. Burns are caused by the explosion of shells, bombs, powder magazines on shipboard, munition stores in medium and large tanks, steam and scalding water. Men escaping a sinking ship often suffer rope burns as they lower themselves over the side, and survivors are burned by the sun as they drift on the sea in open boats.

To fully understand why the use of mechanic's waste made such a spectacular contribution to war medicine, we must first understand the truth in the Navy Medical Department's axiom that "burn patients do not die of burns." These men die from a number of complications, shock being the most common. Military medical statistics show that in burn cases, shock is the real killer in about two-thirds of casualties, with various types of infections and poisoning claiming the rest.

Shock is still a huge problem to the medical profession.

Outstanding physiologists have been unable to give a satisfactory explanation of it, but one fact is certain—it is the cause of the "white bleeding" that often proves so fatal to the patient. "White bleeding" was the term applied by Dr. Sumner L. Koch, of Northwestern University Medical School, to explain the rapid oozing of the white, or fluid, part of the patient's blood, from the capillaries which suddenly appear unable to hold the victim's blood stream.

Often a large blood vessel is cut or torn when a man is wounded and this causes the loss of a large amount of red blood, which, in turn, induces a shock condition. But in burns the white bleeding, the patient's own blood plasma, usually causes all the trouble. It forms blisters and the burned flesh "weeps" large amounts of the vital fluid. This weeping causes a drop in the patient's blood pressure. The body cannot receive enough blood-borne oxygen to stave off the shock condition and death often results.

And that is where the handful of mechanic's waste plays such an important role in modern burn therapy. Placed over the burned area it checks the vital white fluid, forcing it back into the capillaries, and from there into the veins and arteries, and thereby either preventing or slowing down further leakage. And while no one claims the new type of "pressure dressing," using the mechanic's waste, replaces the use of blood plasma transfusions in fighting shock, nevertheless military physicians report that where it is used the patient requires less blood plasma.

In addition, it is generally agreed that the waste material pressure bandage, when applied properly, does something else for the burn victim: not only does it help hold off shock but it eases agonizing pain almost at once. It splints the injured part and cuts down the time spent in hospitalization. The waste pressure bandage, left over an uninfected wound for ten days to four weeks, reduces the number of dressings necessary. These changes are painful and, when frequent, provide an opportunity for germs to enter the wound. The pressure bandage also minimizes tissue destruction and therefore subsequent scarring and disfiguring—the thing burn victims fear most—and where the handful of waste is such a great help to military plastic surgeons.

While the application of mechanic's waste as a pressure bandage may be new since the outbreak of World War Two, actually the principle is an old one, dating as far back as the Egyptians. Lieutenant Colonel James Barrett Brown, chief of plastic surgery at Valley Forge General Hospital, is certain that it dates back to the pyramids. In the famous Papyrus, translated by Edwin Smith, there is a recommendation for the treating of a broken nose by placing "two stiff rolls of linen, bound on." That was about 3,000 B.C. The Egyptians were experts in bandaging, as is proven by the wrappings around their mummies; and the rolls of linen, apparently supported by additional soft rolls as splints, are regarded by Lieutenant Colonel Brown as the earliest known reference to pressure bandages.

Now, plastic surgeons are by nature ingenious and resourceful. They have to be able to persuade transplanted skin and bones to take root and grow in new locations. They were among the first modern physicians to appreciate the value of pressure bandage dressings, and they began to employ them about twenty years ago on the site of skin grafts. Dr. Vilray P. Blair, of St. Louis, and Dr. John Staige Davis, of Johns Hopkins, both plastic surgeons, were the earliest advocates of marine sponges for this purpose. Colonel Brown, then associate professor of clinical surgery at Washington University, St. Louis, was also using sponge pressure dressings back in 1920. Sponges, though satisfactory, cost a dollar and a half each and were not always available. So one day in 1935 Dr. Bradford Cannon, a young surgeon on Dr. Brown's staff, went to the St. Louis railroad yards and bought a supply of mechanic's waste in the railroad's machine shop for twelve cents a pound. It was not only cheaper than sponges, but he and Dr. Brown found it was better because it worked more easily into small corners, such as spaces between the fingers. Today, instead of the coarser grades of waste, they use a softer, shorter-fibered type that has no lumps to cause undue pressure at certain points.

In 1939, Dr. Koch, of Northwestern University Medical School, and his associate, Dr. H. S. Allen, began to employ the pressure bandage in treating burn cases in the children's ward of the Cook County Hospital, Chicago, and noted a marked decrease in the mortality rate as compared with the preceding years when the tannic acid method was used.

Physicians took up the compression technique—Dr. Henry A. Royster, of Cleveland; Dr. Vintor E. Siler, of Cincinnati; Dr. Neal Owens, of Tulane University Medical School, to name a few of the pioneers. Dr. Owens has wrapped severely burned children and adults almost from head to foot in these thickly padded bandages, and has seen the falling blood pressure of the patients in shock climb quickly back toward normal.

The Army, Navy and Office of Civilian Defense now recommend this new type of dressing. The Surgeon General of the Army recently issued a circular letter specifying pressure dressings for treating burns, both in hospitals and on the field, and ruling out tannic acid, which was so widely used during the past few years. He also ruled out all other escharotics—substances which produce a crust over the burned areas. Several months earlier the Surgeon General of the Navy, Admiral Ross McIntyre, issued similar orders. The medical division of the OCD has revised its manual on burns and wounds to withdraw its recommendation of tannic acid, taught a year ago in first-aid classes, and to prescribe the pressure bandage instead. Under the dressing, the first-aider may use petrolatum or ointments of boric acid or sulfathiazole. In adopting the new technique, the services were guided to a large extent by the recommendations of the National Research Council's subcommittee on burns.

At Valley Forge General Hospital, bale after bale of the fluffy white waste is being used in various phases of plastic surgery resulting from burn wounds. Under Colonel Brown and his associates, including Captain Cannon, who treated many of the victims of Boston's ill-fated night club fire,* Valley Forge has become one of the world's greatest plastic surgery centers. Here burned flesh is covered with new skin, shattered faces are rebuilt, twisted hands are straightened and restored to usefulness, legs are limbered so men may walk again. The road from the battlefields to Valley Forge Hospital is a hard, well-traveled one in this war. But the road back is bright with the gleaming hope of the future.

The Navy, too, has taken great steps toward bringing its burn therapy and plastic surgery up to date. But it has also enforced regulations designed to protect men from burns. Passing ammunition while dressed in shorts and scivay shirts is strictly forbidden. Full clothing must be worn at battle stations, no matter how hot the weather. Trousers must be stuffed in tops of socks, cuffs and collars must be securely buttoned. Special anti-flash gear is sometimes worn. A group of naval scientists at the Naval Medical Center, Bethesda, Maryland, has developed an anti-flash burn cream for hands and faces. They bared their own arms to miniature cannon blasts in the course of testing the cream, which contains titanium dioxide, the non-toxic white pigment used in paints.

Despite the most careful precautions, however, men at war cannot always escape the battle flames. For this reason, the treatment, as well as the prevention, of burns was an inevitable discussion one day late in July, 1942, when Commander Bart Hogan, medical officer of the *USS Wasp,* came aboard the hospital ship *Solace,* somewhere in the Pacific, to pay a professional call on Captain Richard A. Kern and Captain Lewis Keer Ferguson. Tall, slow-spoken, Dr. Kern is, in civilian life, professor of clinical medicine at the University of Pennsylvania. Doctor Ferguson is assistant professor of surgery at the same university. At this time they were chiefs of medicine and surgery, respectively, aboard the 500-bed hospital ship.

"We discussed with Commander Hogan the various methods of treating burns," Captain Ferguson said, "and we reviewed the excellent results we had been having with pressure dressings and sulfathiazole ointment. It was agreed that all of us would follow this technique whenever practicable, and Commander Hogan, on returning to the *Wasp,* fixed up quantities of the ointment-soaked gauze and packed it in cans, ready for use."

Less than two months after this shipboard medical conference, Commander Hogan and his newly prepared supplies were called upon for one of the toughest assignments, in medical terms, in the Navy's war. Three Japanese torpedoes crashed into the *Wasp* off the New Hebrides. It was a death blow. The carrier's magazine exploded.

Her fuel tanks burst and spilled their blazing contents onto the ocean. Many of the crew had no recourse but to jump from the burning vessel into the fire-covered water. On the crowded decks of the rescue destroyers, Commander Hogan and his medical assistants and hospital corpsmen labored over the wounded, going 48 hours without rest or sleep, first injecting morphine to ease the pain, then gently bathing away dirt and oil and charred skin, and finally binding pressure dressings on the burns. Often they used only mechanic's waste brought up from the engine room and sterilized in steam. Within four days after the sinking, the *Wasp's* wounded were resting between the cool sheets of the *Solace* and a few weeks later they were joined by the badly injured survivors of the *Hornet,* sunk in a later battle off Santa Cruz.

During a year's service in the Pacific, taking on wounded from many other fighting ships, the *Solace* cared for some 360 burn cases, of whom 303 were battle casualties. Some were received a few minutes after the action. Most, however, were transferred to the *Solace's* wards two days to several weeks after the disaster, having in the meantime been treated by other physicians and by a variety of methods. The *Solace* staff thus had an opportunity to evaluate various types of burn treatments on the basis of results seen with their own eyes. In a complete report on these 360 cases, published recently in the Naval Medical Bulletin, they strongly recommend pressure dressings, applied over a coating of sulfathiazole, as the best method. Of the 360 burn cases considered in the *Solace* report, only three died and the staff attributed two of these deaths to other injuries suffered at the same time.

The one *Solace* death due to burns was that of a sailor whose severely scorched skin had been treated with tannic acid before he had been brought aboard the hospital ship. The physicians found toxic damage to the liver during a post-mortem examination and blamed this, at least in part, on the tannic acid.

The original theory of tannic acid treatment was that by quickly coagulating the burned skin, it "locked" in place the toxic products believed to be generated in the burned tissues, thus preventing them from spreading into the patient's system. But as the *Solace's* doctors and others eventually concluded, the disadvantages far overbalance the benefits. The acid often killed good healthy skin, turning a second degree burn into a third-degree injury. Infections under the "tan" crust were exasperatingly difficult to control. The toxic injury to the liver was frequently noted. Furthermore, the tanning treatment was much more painful than the firm, but resilient cushion of the pressure bandage.

One man who was treated by both the tannic acid and the pressure bandage techniques at the same time was left with no doubt as to which was the more comfortable. Showered with flaming gasoline in an explosion, he suffered painful third-degree burns of the face, ears and neck, also of the chest and the upper arms. The surgeon, Colonel John J. Gallagher, of the Army Medical Corps, swathed the patient's face, head and neck with thick, fluffy pressure dressings, leaving only slits for his eyes and another for his mouth. The man's hands and forearms, seared with second-degree burns, were also pressure bandaged. But his chest and upper arms were sprayed with tannic acid-silver nitrate solution, according to the then accepted procedure, and were not bandaged.

From the very moment the pressure bandages were applied, they stopped the pain in the areas they covered, and no swellings or blisters formed under them. But huge blisters developed under the tannic acid crust, which had to be lanced in several places to permit drainage. At the end of the third day, the doctor wrote in his report: "Thus far the patient has directed his complaints to the tannic acid areas, claiming complete comfort for the hands, forearms and head"—the parts which had been pressure bandaged. After ten days the dressings were removed from the head and right forearm, revealing clean, unswollen skin, healing without scars.

Colonel Gallagher also observed that the pressure bandaged regions had healed more rapidly than those parts burned to the same degree, but which had been treated with tannic acid. The only spots requiring skin grafts were on the chest, which had been sprayed with the tannic acid-silver nitrate solution.

Although cotton waste has become the accepted padding in most of the hospitals which employ the pressure method, originality and resourcefulness have brought a number of other materials into the picture at various times when an emergency existed. One example of an ingenious application of the waste padding method is offered in the experience of Colonel I. S. Ravdin, a member of the University of Pennsylvania Medical School faculty who is now in charge of a United States Army General Hospital in India. At one time the supplies on the pressure bandage ran alarmingly low. So Majors Norman Freeman and Julian Johnson were assigned the task of scouting the native bazaars to see what they could uncover in the way of a substitute. After hours of fruitless searching, they suddenly spotted a bale of crude Indian hemp. The two Army medical men immediately saw its possibilities. They bought the bale, had it hauled back to the hospital and then set to work. A primitive carding tool was made by driving nails through a board and the hemp was combed out until it was soft and fluffy. After it was sterilized it formed an excellent substitute for American cotton waste.

Meanwhile, to save space in shipping these vital dressing materials to the theaters of war, Colonel Gallagher has designed what might be termed the "compressed pressure bandage." Individual pads are made up from waste, covered with several pieces of gauze. These are squeezed down in a press, so that each is only a fraction of its original size, or about as large as a pack of cigarettes. The Army surgeon has worked out a first-aid unit for hospital corpsmen which consists of an eight-inch cubical box into which sixteen of the ready-made dressings, each with a roll bandage for fastening it on, are snugly packed. When the package is opened, each pressure pad expands to its original size, or to a pad large enough to cover an area nine inches square.

Colonel Gallagher recommends these bandages not only for burns but for other open wounds. They may be employed in some instances as a safe and easy to use substitute for the treacherous tourniquet. The Journal of the American Medical Association, in fact, has stated editorially that compression dressings of this type may become standard equipment for all first-aid kits and has urged that policemen, firemen, nurses' aides, trolley and bus operators and workers in industry familiarize themselves with the proper application.

So the lowly handful of mechanic's cotton waste has become one of the important factors in modern medicine. This Cinderella of the machine shops has joined the distinguished company of sutures, scalpels, penicillin and the sulfa drugs.

But the pressure treatment, using the cotton waste, was not the only burn therapy developed since Pearl Harbor. Another treatment was devised by a Navy medical officer on duty at Mare Island because that particular officer did not believe pressure bandages were the last word in curing burns. As soon as it was possible to move them, the Navy Department transferred 97 sailors from Pearl Harbor to the Mare Island Base Hospital, after they received emergency treatment for burns received during the December 7th attack. At Mare Island they were placed in the burns ward under the supervision of Lieutenant Commander Ralph Cooper Pendleton, of the Navy Medical Corps.

Dr. Pendleton, according to his own story, had been a hoarder. He had saved some fifty "flit" guns, feeling that some day he would be able to use them. Now, with these young sailors in intense pain from the burn wounds actually begging him to do something to lessen their pain, he suddenly realized how those guns could be used. Working out a mixture of melted paraffin wax, vaseline, cod liver oil and sulfanilimide and adding just a touch of camphor, menthol and eucalyptus oil. Dr. Pendleton sprayed the solution on the sailors' burns with his flit guns. The entire treatment consisted of washing, or rather gently swabbing, the burn area with lukewarm water and then renewing the solution from the spray. The burns were not washed before the first application, but merely dusted lightly with sulfa powder. The remainder of the treatment included the high protein diet and whole blood or plasma transfusions usually prescribed in burn cases.

Dr. Pendleton's treatment showed almost instantaneous results. The sailors reported an immediate reduction in pain and, eventually, no pain at all. Just what action the wax had on the wounds is not fully understood by the

Navy medical authorities, but they believe it coats the bared nerve tips and protects them from cold and air, the source of much pain to burn victims. The reduction of pain enabled Dr. Pendleton to eliminate morphine as an opiate. He said this was a step toward quicker recovery, too, since the narcotic caused the patient to become languid, constipated and lose appetite.

Another feature of Dr. Pendleton's treatment is that it eliminates the time-consuming ritual of cleansing and removing dead tissue and blisters from the burns as the necessary first step in burn therapy. The wax treatment also allows for the patients in burn wards to be treated with greater speed than when dressings had to be changed, tannic acid applied, and other therapy given. All this required the attention of badly needed hospital personnel. With the use of the flit gun and the wax solution, Dr. Pendleton proved he was able to treat five patients in the same amount of time it took a doctor to help one under the old methods.

Dr. Pendleton admits his wax treatment has one weak spot. Since he does not advocate the bandaging of burn wounds, the sight of the open wounds is not a pleasant one. However, he and his patients feel the benefits of the flit gun outweigh any considerations over appearance.

This Navy doctor, whose experience with burn therapy has been extensive, is not as enthusiastic as some over the pressure bandage. Dr. Pendleton believes that even the fluffiest pressure dressing has a tendency to injury the delicate skin cells and thus retard complete recovery. He points out that while it eliminates the crust from burns, so does his treatment. The wax does not form any "eschar" over the wound.

As we have seen, burns are a major war problem, especially to the Navy, since so many of its personnel must take their battle stations in closely confined areas where flame can do great damage before it is checked. Because of this factor, Navy doctors are still searching for the answer to burn therapy, and they feel both the cotton waste bandage and the wax treatment are a step in the right direction.

Encouraged by the shouts of his patients—"Quick, Henry, the flit"—when he appears in the wards for treatment, Dr. Pendleton is now working on a small heater, to be powered by a 25-watt light bulb, that will melt wax and make the solution available for emergencies in ships' turrets and other enclosed areas.

We have seen how a handful of mechanic's waste and a flit gun were recruited in the war against burns. Perhaps the most dramatic development in burn therapy, however, was enacted in a Cincinnati laboratory. That development was the birth of Biodyne, called by some physicians the miracle burn ointment. Biodyne, like many other medical discoveries, was uncovered while the investigator was looking for the answer to another problem. The discoverer of the ointment, Dr. George Sperti, of Cincinnati, was making cancer experiments when one of his laboratory assistants suffered severe burns as a result of an ether-extracting operation. While waiting to remove her to a hospital, fellow workers took emergency measures to ease her pain. She was smeared with large quantities of an ointment with which they were experimenting in the course of cancer research. For some unknown reason, which Dr. Sperti himself could not explain, all pain ceased almost immediately and the wounds healed without any scars.

Perhaps the one person least impressed by the achievement was Dr. Sperti. Advising the medical profession of the incident and the results obtained, he returned to his cancer research after making a quantity of the ointment available for use. But if Dr. Sperti was indifferent to his new discovery, other doctors were not. In Chicago, Dr. Thomas P. Walsh, of Mercy Hospital, reported he had tested the ointment in 100 varied burn cases and the results were excellent.

It is necessary to understand the theory Dr. Sperti followed in his research on cancer if we want to understand how the miracle burn ointment, Biodyne, was born. In launching his cancer research, Dr. Sperti first tried to explain the half-understood conduct of cells. Cells are the microscopic building blocks that form our living tissue. Cells, much like humans, behave in a normal, orderly fashion: they breathe, grow, reproduce and enjoy harmony with their neighbors. But occasionally certain cells "go off the reservation"; for no apparent reason they begin to show abnormal growth, consume too much energy and communicate this law-breaking behavior to neighboring cells. When this condition spreads the result can usually be described as cancer.

Dr. Sperti reminded his staff that when living tissues are wounded, the neighboring cells break their routine and multiply themselves at a furious rate until the destroyed tissue has been replaced, and the wound healed. The Cincinnati physician reasoned that some substance must control and stimulate this cell metabolism. If that substance could be found then, perhaps, you have the key to cell activity and a possible cure for cancer.

The initial step was with ultraviolet rays in controlled doses to produce injury to cell tissues of chicken embryos, animal livers and fish. After a predetermined injury had reached the proper degree, the wounded tissue was bathed in a solution. The cells themselves were filtered through the solution. And, under the microscope, Dr. Sperti saw the life cell yield one of its most closely guarded secrets: for there in the sterile, cell-free fluid was a mysterious chemical that had been released by the ultraviolet ray injury. When other living tissues were submerged in the solution, the experimenters could see the furious speed-up of cell multiplication. Awed in the presence of this chemical, one of Dr. Sperti's colleagues reverently supplied it with a name: Biodyne, from the Greek "bios," meaning life, and the Greek "dyne," meaning force.

But the cells had still another surprise in store for the men seeking to solve their mysteries. The investigators discovered there are different kinds of Biodyne. One type stimulates the growth and reproduction of cells, playing an important role in the healing of wounds. The scientists called this the proliferation-promotion factor. Another type stimulates the cells' respiratory action while still others aid the cells in speeding up sugar consumption for energy.

It can readily be seen that the first type, the proliferation-promoting factor, would be the important one in burn therapy where often large areas of new tissue must be grown quickly. So, it was from the growth biodynes, obtained from artificially injured animal livers, and the respiratory biodynes, obtained from injured yeast cells, that the burn ointment—two types of biodynes and a grease base—was compounded. Why its effect is so magical, just why it relieves pain so quickly, is still a medical mystery, for the ointment contains no local anesthetic.

6. Penicillin

ON A HOSPITAL BED in the great Walter Reed Hospital in Washington, a 23-year-old Coast Artilleryman lay virtually in a coma. About his bed a screen had been placed. Most of his fellow patients knew what that portended. The end was near.

The soldier, Pvt. Herbert F. Collins, of Holyoke, Mass., was suffering from a brain abscess, which apparently was fed by an earlier lung abscess. There was no medical record of any recovery from such a secondary brain abscess. Two surgeons, an interne and two nurses stood by. "There's no hope now," said one of the surgeons, shaking his head. "We've tried everything and he doesn't respond."

"There's only one thing left—penicillin," said the other surgeon. "I doubt if it will do any good, but as a final resort—"

Collins was in a coma when the first injection was given him. It was injected into his muscles. He didn't die. The nurses and internes rigged up a hospital drip and administered the penicillin that way. Collins was still alive. A spark of hope was born. Finally, they injected the penicillin directly into the brain cavity.

He received 480,000 units daily—less than a teaspoonful—for 53 days. But three days after he had received his first penicillin injection, his condition had so improved that he roused himself and told a joke. He improved for a time, then his condition grew worse. But electro-encephalograms showed the formerly diffuse abscess had localized itself at the base of the brain. An operation was performed, the abscess removed. Collins lived to walk out of the hospital—saved by penicillin.

What is this wonder-drug, penicillin, that mushroomed from a laboratory curiosity to an industry in the short space of two years? Actually, we don't know yet exactly what it is—but we do know that we have it and we know what it does.

Penicillin, like many of man's greatest findings, came on the medical scene exactly at the critical moment. For decades, Army doctors have been searching for a drug that would cure infections in open wounds.

The sulfa drugs proved to be of great help, but they weren't always completely effective against pus-forming bacteria. Penicillin has cleared infected wounds that had defied all the usual treatments.

Types of pneumonia that resisted all other treatments disappeared when penicillin was administered. Boils, abscesses, infected burns, osteomyelitis, that terrible bone-wasting disease, and dozens of other less familiar illnesses yielded to penicillin treatment.

Bacterial endocarditis in its sub-acute form, from which there was previously no hope for recovery, proved to be curable under penicillin injections.

Gonorrhea vanished within a few days when penicillin was used on sufferers. Syphilis, too, can be cured through the use of penicillin. Anthrax and lung infections—these, too, are conquered by the new discovery.

What, then, is penicillin?

It is a rare drug secreted by a greenish-blue mold, not unlike the familiar mold that forms on bread, cheese, spoiled fruit, and other foodstuffs.

Molds are fungus growths. There are thousands of them, but they hold only an humble place in the vegetable kingdom. They are non-flowering plants, of which the most familiar example is probably the mushroom. The particular kind of mold from which penicillin is secreted is technically named *penicillium Chrosogenum notatum*. Its spores, or reproductive bodies, are microscopic: they are carried by the wind.

It was this fact that started the chain that led to the discovery of the marvelous properties of penicillin.

In 1929, in a little, cluttered-up laboratory in St. Mary's Hospital in London, Dr. Alexander Fleming, a bacteriologist, was busy with research on influenza. He had left a culture plateful of staphylococcus germs out in the open. The next time he looked at it, he noticed a spot of mold on the plate. This was not an uncommon experience when culture plates were left in the open. Ordinarily, he would have discarded the plate.

But something prompted him to look more closely at it. All around the mold, like a no-man's land, was a clear zone. He looked at the surrounding ring under a microscope. He was amazed to find it entirely clear of the deadly staphylococcus germs.

For some reason the bacteria died when they entered it. Evidently some substances in the mold, or given off by it, were deadly to the germs.

Interesting, indeed, were Dr. Fleming's own thoughts at the moment. He has reported them himself. "Nothing is more certain," he said, "than that when I saw the bacteria fading away, I had no suspicion that I had got a clue to the most powerful therapeutic substance yet used to defeat bacterial infections in the human body. But the appearance of that culture plate was such that I thought it should not be neglected."

Nor was it neglected. Dr. Fleming went to work on that mold, made pure cultures of it. Most of the penicillin produced in the world up to now has been obtained from the descendants of his original colony.

He spent years in test-tube experiments on many other types of bacteria, using the strongest solutions he could get of the strange substance secreted by his *penicillium* mold. The results were mixed.

Most surprising fact of all he discovered was that the secretion did not damage blood corpuscles. That was indeed "something to bite on," as he put it. He had been testing all kinds of antiseptics in human blood for many years, but never before came across one that did not work greater damage to the blood corpuscles than to the bacteria sought to be inhibited.

To the mysterious factor that his mold produced Fleming gave the name penicillin. He wrote an article on his research and his findings, and it was published in a scientific journal. Thereafter, like many other original scientific discoveries, it seemed to be forgotten. Dr. Fleming's work attracted little attention because his announcement came at the wrong time. It was the day of the sulfa drugs, whose potentialities were just beginning to be understood, and scientists were once again enthused with the idea of exterminating disease through man-made chemicals.

In April, 1936, Raymond B. Fosdick, president of the Rockefeller Foundation, received a letter from Dr. H. W. Florey, professor of pathology at Oxford University, saying he believed Dr. Fleming had made a discovery of incalculable value. Dr. Florey was a former Rockefeller Fellow, and his opinion carried great weight at the Foundation.

He asked for a grant of $1,280 to purchase the laboratory equipment needed to prove the value of penicillin clinically. Of course, the grant was made immediately. In his later report, Mr. Fosdick noted that "seldom has so small a grant led to such momentous results."

A further grant was made and by 1939, Dr. Florey and his associates at Oxford were really at work in penicillin in earnest. They discovered that if they grew *penicillium* in a liquid under favorable conditions, something somehow was added that killed bacteria.

In their Oxonian laboratories, they grew *penicillium* by the square yard, its greenish-gray growth spreading under water in specially constructed basins. After a while they would pour off the liquid in which it grew and try to extract from it the essential compound.

Now, extraction of one compound from a mixture of several can be very simple, or it can be very complex. To extract salt from salt water, all you have to do is boil the water off. To extract fat from a piece of meat, you simply pour ether over the meat, let the ether dissolve the fat and then evaporate the ether from the fat-and-ether mixture.

To extract penicillin was a far more complex problem. Its properties were unknown, it was exceedingly unstable and with it were mixed a number of other organic substances any one of which, as far as was then known, might have been a part of it or a necessary element in its work.

Said Dr. Fleming himself: "Penicillin production is not all mold culture. This mold, *penicillium notatum,* is at present the only thing that can make penicillin, but it can only make it in dilute solution, and the solution it makes contains other substances which, if left there, destroy the active penicillin.

"This is where the chemist comes into his own. He cannot make penicillin, but after the mold has done its best and made the dilute solution he can concentrate it, remove the injurious impurities and eventually dry it so that its potency can be preserved.

"Penicillin is easily destroyed, so that the chemical operations which are undertaken in its purification have to be conducted with the greatest care. Otherwise what was originally an active, if dilute, solution becomes inert. This is one of the many things which has prevented its unlimited production."

At any rate, Dr. Florey and his associates continued to work with the extract from the mold. The job was difficult. At times it seemed hopeless, but they persisted. Another grant was obtained from the Rockefeller Foundation, and ultimately a third.

In time, they were able to concentrate the extract from the penicillium mold to 1,000 times the strength of the original secretion.

First laboratory tests on living creatures were made with this 1,000-strength extract on mice. The little mice showed no deleterious effects. Into other mice the laboratory technicians shot doses of bacteria producing "incurable" diseases. They waited for the disease symptoms to show up, then injected the sick mice with penicillin. Lo and behold, the mice recovered!

By 1941, Dr. Florey's research team had refined the penicillin extract to the point where it was considered pure enough, and sufficient clinical evidence had been obtained to show that it was non-toxic. They were now ready to experiment on human beings.

Penicillin was first used on desperately, hopelessly ill patients in 1941. It produced results that were considered miraculous. Since then, of course, the range of penicillin's potentialities has been broadened by added research.

Dr. Florey came to America. He introduced penicillin to the American medical fraternity. To the doctors here he showed that although other drugs might kill bacteria in less time than penicillin did, they had some very bad effects in cases. It was just about the time when scientists were discovering that the sulfa drugs, despite their amazing results, raised allergies in some patients, and in a large number of cases, worked permanent harm.

The wonder of penicillin was that it destroyed the bacteria in the body that were the cause of disease, but did no harm to the patient. Regardless of the age or disease-weakened state of the patient, penicillin was harmless.

Dr. Fleming likened his discovery to reinforcements for front line troops who are threatened by annihilation by the advance of an invading army. The invading army, in the case of a patient, would be the disease-producing bacteria. While acting as reinforcements from the white cells in the blood stream of a patient, penicillin also prevented the possibility of the invader, or bacteria, from bringing up reinforcements—thus turning the tide of battle for the white corpuscles.

Moreover, penicillin worked effectively against some bacteria which the sulfa drugs could not cope with, particularly the pus-forming bacteria that gather in open cuts and wounds, which are unaffected by the sulfa drug group.

What does penicillin do? Let's take the word of its discoverer, Dr. Fleming, again. "As regards the staphylococcus, a microbe which is perhaps the most common cause of infection in man," said Dr. Fleming, "the purest penicillin which can be produced is so potent that if it is diluted about eighty million times it will completely stop microbe growth. In concentrations five or more times weaker than this, the microbes grow but when examined microscopically, they have peculiar appearances, and although they are growing, they are not dividing properly.

"To make this illustration more graphic, the volume necessary to dilute one drop of fluid one hundred million times is nine thousand pints. There is no other substance which approaches penicillin in potency, and the staphylococcus is not the most sensitive. The streptococcus, which is perhaps the most serious infection in man, and which in the last war was a constant infection of war wounds, is even more sensitive and so is the pneumococcus, which causes pneumonia.

"So is the meningococcus, which causes meningitis, and the gonococcus, which is the infection in most common venereal diseases.

"Many other microbes, including the spirochete of syphilis, are sensitive, but of the serious infections, the following are quite unaffected by penicillin: typhoid, paratyphoid, dysentery, cholera, plague, tuberculosis and whooping cough, as well, so far as we know, as the virus diseases such as smallpox, measles and influenza."

When the Japanese struck at Pearl Harbor, production of penicillin, which up to that time had been conducted only on a laboratory scale, swung into high gear. It was given the highest priority. Manufacture was strictly controlled; in fact, the process is still a military secret. Distribution was confined purely to the fighting forces for a long time. The Government encouraged some 21 chemical firms to set up plants for mass production of penicillin, and allocated $20,000,000 for the purpose. Twenty-two groups of researchers were promised supplies of penicillin to carry out experiments in hospitals and university laboratories throughout the country; the Army and Navy also assigned experts to do similar work in their hospitals.

Before very long, American mass production methods had increased the supply of penicillin beyond all expectations. In general, there were three methods used: surface culture, bran culture (in which the mold is grown on bran moistened by a liquid nutrient), and submerged culture.

In submerged culture, the mold is grown in huge covered vats. Each vat holds several thousand gallons of nutrient fluid. The preferred culture medium is corn steep liquor. Of course, for growth fresh air is necessary, so fresh air is pumped through the fluid.

After several days, when it appears that the mold has produced a sufficient supply of penicillin, the fluid is piped off to other containers where it is concentrated at low temperatures and under high vacuum conditions somewhat like the technique used in drying blood plasma.

Between June, 1943, and March, 1944, production of penicillin had increased a hundredfold. The March, 1944, production was about 1.7 pounds per day; the ultimate goal was 9 pounds per day. The drug is administered in units. There are 1650 units in one milligram, which means there are about 750,000,000 units to the pound.

It is interesting to note that the first price quoted for penicillin, and acknowledged to be less than its cost to produce, was $20 per 100,000 units, which was at the rate of about $150,000 per pound. The price quoted in 1944 was $3.25 per 100,000 units, a reduction of 84 per cent.

On the average, physicians hold that severe cases requiring penicillin treatment will need about 1,000,000 units, except for gonorrhea, which requires only from 100,000 to 150,000 units. Thus, at $3.25 per 100,000 units a severe septicemia (blood poisoning) could be treated for $35; or a sulfa-resistant gonorrhea for less than $5. However, with the constantly improving methods of production, it is safe to say the price will go much lower, and penicillin will be within reach of everyone.

In preparing penicillin for use, it must be concentrated some twenty thousand times, or until it is completely dry, before it can be stored without fear of deterioration. It arrives at the hospital where it is to be used as a yellow or yellow-brown powder, and is then stored in refrigerators until it is needed.

To be used, it is diluted with distilled water and jabbed with a hypodermic needle into the muscles. As an alternative, it may be allowed to drip into the vein in a glucose mixture, but it need not necessarily be administered near the point of infection.

Although five gallons of culture fluid are needed to yield a single gram of penicillin, the potency of the drug is extremely high. It requires only one part in twenty-five million to stop the growth of the pus-forming germ, *staphylococcus aureus,* which causes boils.

When the action of penicillin came to be known to physicians, many of them asked: "Since penicillin is so powerful, why not simply lay some of the mold on a wound and let it secrete penicillin?" Dr. Florey showed that this was not feasible for several reasons. One was that the mold is dirty, and would carry more infection than the penicillin could destroy. Another is that the mold is temperamental: it will grow virtually everywhere, but it will not secrete penicillin unless conditions are exactly right. It sometimes balks even under conditions considered perfect by scientists; it will grow, but it will not secrete the drug.

One of the most important goals of the groups of researchers now working on penicillin problems is to synthesize the drug with known chemicals, in the same manner as some of the vitamins have been synthesized. That poses quite a problem. Scientists have not yet been able to decide what penicillin is made of, or what its particular molecular structure is.

Another factor is that nobody knows for certain yet how penicillin does what it does to the bacteria in the body. Science believes it knows what makes the sulfa drugs so effective. The theory is that the drug is absorbed by the disease-producing germs and that it then somehow prevents them from digesting an acid produced in the body which is one of the essential elements in the germ's diet. So they starve to death. Other germ-destroying agents do their work by upsetting the osmotic balance of the bacteria, causing the latter to absorb so much liquid that they expand, ultimately blowing themselves up.

Penicillin is known to work slowly. Its effect may not be felt for hours, as compared with the minutes in which a number of bactericides do their work. This has led to the theory that penicillin doesn't kill the offending germs; it merely upsets their process of reproduction. This would be sufficient to arrest the spread of disease, for if the total number of offending bacteria can be kept constant, the white blood cells will ultimately outnumber them, over-power them and clean them out. This will manifest itself in the recovery of the patient.

Bacteria multiply exceedingly fast. It has been estimated that under proper conditions, a single germ will produce one billion descendants in fifteen hours. Thus it can be seen that if the multiplication of disease-producing bacteria in the body is not halted, they can become so numerous that the body cannot cope with them. As a matter of fact, this is the fundamental process of disease.

Penicillin has now reached the stage at which its efficiency in a wide variety of diseases has been fully established, although its full clinical potentialities are yet to be realized. Obviously, before even a fraction of the ultimate world-wide demand for the drug can be supplied, there will have to be an enormous increase in production.

The manufacture of penicillin is attended with many difficulties. It involves delicate microbiologic processes influenced by a host of factors. The slightest variation in any one of these processes is sufficient to alter the potency of the drug. Most important in the preparation of penicillin is the necessity of selecting a high-potency strain of *penicillium notatum,* since strains of the mold from different sources vary widely in their ability to produce the drug.

Having chosen the stock culture, measures must be taken to prevent a spontaneous loss of penicillin-producing power. This is usually achieved by mixing a watery suspension of the spores with dry sterilized sand or soil, and drying the mixture in a frozen state. These cultures then constitute the master stock cultures and can be preserved indefinitely in a refrigerator.

To start the process of manufacture, a loopful of the soil-spore mixture is spread evenly over the surface of solidified agar, which is then incubated for from four to six days. By that time, the mold has developed uniformly over the surface of the agar to form a large colony of grass-green spores.

These spores are used to inoculate dozens of Roux bottles containing the same culture medium, agar, and these in turn provide material to inoculate several hundred flasks of liquid medium which, after the growth of the mold, is known as penicillin broth. The flasks of inoculated liquid culture media are now allowed to stand for from one to two weeks.

The spores, floating on the surface, first germinate and form white cottony, vegetative patches on the surface. These gradually spread until a thin mat is formed over the entire surface of the liquid.

At the same time a yellow pigment, chrysogenin, is exuded into the culture medium. On the sixth day, the white vegetative growth on the surface of the mat begins to be replaced by green spores. With increased age, the pellicle begins to wrinkle, until finally the surface is marked by innumerable convolutions.

During this incubation process, penicillin is being exuded into the medium. The amount of drug so produced depends upon a variety of factors, among which the nature of the culture medium is of prime importance. For one thing, if the alkalinity drops below a certain critical level and stays there, a second antibacterial substance, called notatin, or penatin (penicillin B) may be formed. At the same time, the production of penicillin decreases.

The presence or absence of certain substances in quantities as small as only a trace, particularly zinc, may influence penicillin production to a marked degree.

As the growth of the mold goes forward, the liquid medium is periodically assayed for penicillin, and it thus becomes possible to harvest the drug at the time of the peak penicillin production. The liquid medium is separated from the mold material by filtering the mixture or by putting it through a centrifuge. The filtered broth is then extracted with organic solvents, and the final product obtained is an aqueous solution of the sodium salt of penicillin. From the orange-yellow solution of the sodium salt, a light orange-colored powder is obtained, in which form the drug is used clinically.

How penicillin saved the lives of two soldiers stricken with meningitis in mid-Atlantic while en route to overseas stations was disclosed by Major General Homer M. Groninger, commanding general of the New York Port of Embarkation. Realizing the great efficacy of the drug, but limited in its supply because of the great need elsewhere, outbound troop transports were supplied only a limited amount of penicillin—about enough to treat from two to five critical cases.

One such case described by General Groninger was that of a soldier stricken with cerebrospinal meningitis. Sulfa drugs were administered, but the patient did not respond. When he was sinking, and the physicians had about given him up, penicillin was administered as a last resort. Overnight an improvement in his condition was noted, and the soldier ultimately recovered.

In the second case, which occurred on the last day of the outbound voyage of another transport, the condition of the soldier appeared to be hopeless. After little response to sulfa drugs, penicillin was injected, fever vanished, and it was possible to transfer the patient to a base hospital on debarkation.

How far is penicillin going to go in saving human lives? The answer to that question is a question in itself. Nobody knows. It was reported that living cancerous tissues of rats and mice have been treated with penicillin and the cancer cells were killed but the drug did no harm to normal cells. This research has been carried on by Corporal Ivor Cornman, technician of the Walter Reed Hospital. Dr. Cornman pointed out, in announcing his discovery, that it does not mean a cure for cancer has been found, but that it opens a new approach, with experiments on human tissues expected to follow.

Although scientists have not yet been able to ascertain the chemical composition of the penicillin molecule, they believe that the active substance in the drug is an enzyme. According to theory, if a disease-producing germ is visualized as a brick house, the enzyme in penicillin can be pictured as destroying essential supporting parts until the whole of the structure crumbles into a pile of its component bricks. This process is called "lysis" in science. To produce this effect, the penicillin enzyme appears to go on a rampage of destruction, which is contrary to the general behavior of enzymes in the body. Ordinarily, they would act as the creators of molecules out of the raw materials taken into the body. By processes which are still unknown to biochemists, enzymes are able to cause in living organisms chemical reactions which in non-living matter require high temperatures, high pressures or other extreme conditions. The number of enzymes in the body is unknown, but it is obvious that they must be very numerous, for there appears to be one for each specific chemical reaction.

As a result of the spectacular performance of penicillin, there will undoubtedly be a tremendous burst of activity in research laboratories, as soon as this becomes possible, to locate other enzymes with similar deadly effects on disease germs upon which penicillin exerts no effect.

The antibodies which the body produces in its normal battle against invading disease germs owe their power to destroy bacteria to specific enzymes which match the germs. The use of an enzyme such as penicillin is an extension of the technique of nature, another great step forward in science by man.

7. Blood Plasma

MORE THAN ANY other development in modern medicine, blood plasma stands as a symbol of man's sympathy and compassion for his stricken fellows. Blood donors willingly volunteer to give their very life blood that others, wounded on the far-flung battlefronts of the world, may live.

Twenty years ago a young pathologist, working in the Bryn Mawr Hospital, just outside Philadelphia, made the first great advance in the use of plasma when he proved the fluid could replace whole blood in cases where transfusions were necessary. But his role in the plasma drama had a prelude. In 1900, a young Viennese doctor, Karl Landsteiner, discovered that not all blood types are the same and that in transfusions, the donor's blood must match the patient's or the corpuscles will clot and the results turn out disastrously. The problem of clotting, or clumping, was solved a dozen years later when Drs. Richard Lewisohn and L. Agote announced that the addition of sodium citrate to the blood eliminated the difficulty.

Meanwhile, Dr. Richard Weil, working in New York, was experimenting with the possibility of preserving blood for indefinite periods. He finally met with success and in 1915 he was able to announce that sodium citrate—in larger quantities than used to prevent clotting—would preserve human blood for about five days and still be transfused successfully.

Then came the usual paradox—the paradox that runs like a brightly colored thread through the history of most great medical achievements. For in the horrible crucible of World War One was born the idea that was to grow into the life saving plasma of World War Two. In 1918 the battlefields of Belgium and France were covered with men who had died from shock and hemorrhage because there was no way whole blood could be transported to them before it spoiled and no assurance that the proper types would be available in sufficient quantities.

Worried over this phase of military medicine, Captain Gordon R. Ward, of the British Army, wrote in the British Medical Journal of March, 1918:

"I have been reading with great interest recent articles on blood transfusions in casualty clearing stations. Apparently one of the chief troubles is the question of whether or not the recipient's plasma will haemolyze the corpuscles of the donor. Surely the difficulty might be avoided by not transfusing the corpuscles at all, but giving the patient only the citrated plasma, which would be easy to keep and easy to give."

Human blood is divided into two parts. One part, the liquid, is called plasma; the second part, solid, is formed by the corpuscles. Dr. Max M. Strumia, working as a pathologist in a Philadelphia hospital in 1925, joined thoughts across the years with Captain Ward and began to wonder what would occur if the corpuscles, which, incidentally, make the "typing" of blood in transfusions necessary, were drawn off and only the liquid, or plasma, used.

Dr. Strumia worked for months on rabbits, extracting the plasma from their blood, and even taking out the fibrinogen, which causes clumping. With the fibrinogen out, the pathologist had a fluid called blood serum. The serum was injected into hundreds of rabbits and their reactions carefully checked. But the rabbits failed to react. In the next step, Dr. Strumia induced shock and hemorrhage and then introduced blood serum into their veins. Now the blood pressure returned to normal and the rabbits recovered. In the last step of his experiments, Dr. Strumia started injecting plasma and here the results were apparent more quickly and recovery was more rapid.

Encouraged with his success working with rabbits, Dr. Strumia felt he was ready to make tests with plasma from human blood. Proceeding with caution, he transfused human blood plasma into patients at his hospital in exceptionally small quantities and, as in the case of the rabbits, the reactions were carefully noted and checked. But, after close study, none showed unfavorable reactions. Plasma, Dr. Strumia proved, did not have to be matched—blood from a total stranger with a different blood type could be injected into a patient without ill effects. However, the young pathologist was not completely satisfied. His results thus far had been excellent, but what if he transfused larger quantities—quantities large enough to bring blood pressure up to normal? After his experiments with the rabbits and the small quantity transfusions on humans, Dr. Strumia was confident of the success of a large scale experiment, but he was unable to find a patient who would consent to the test, unusual in our time.

His chance came in 1927 when a physician's wife was admitted into the hospital, gravely ill. A blood transfusion was urgent. Dr. Strumia was able to obtain the husband's consent to a transfusion of plasma extracted from blood that was not the wife's type and which would have caused serious trouble had it been pumped into her veins whole. The woman came out of her coma, rallied for a few days, but finally died.

In an interview, Dr. Strumia said his hardest struggle in those early days was to bring about the acceptance of plasma by clinicians so that further studies could be made.

"We who were working with it were sure of its value," he said, "but other doctors were slow to let us try it on their patients unless they were doomed."

Seeking a more sympathetic atmosphere, Dr. Strumia moved to the Bryn Mawr Hospital, a few miles west of Philadelphia, where he is still a member of the staff. During the infantile paralysis epidemic of 1932 he had another chance to prove the effectiveness of blood plasma. Physicians, desperate to try anything that might stem the tide of the epidemic, consented to the use of plasma. Here again Dr. Strumia won a Pyrrhic victory—the transfusions did not cure his patients, but neither did it add to their discomfort.

Thus far his successes had been mostly confined to the laboratory, and Dr. Strumia continued his experiments in that environment rather than in the hospital wards. His next discovery was that the plasma could be frozen in solid blocks, and in its frozen condition all biological action was suspended. By this process the plasma could be stored indefinitely.

Then came Dr. Strumia's big opportunity. In the middle of March, 1934, a 12-year-old boy was admitted to Bryn Mawr Hospital suffering from mastoiditis and a blood stream infection. His temperature reading was 107.4 degrees and death seemed inevitable. Transfusions of whole blood were tried, but the results were disheartening. For some unknown reason the blood clotted in the boy's veins and the red corpuscles were demolished. Finally, in desperation, Dr. Percival Nicholson authorized the induction of plasma into the boy's blood stream. The plasma was administered and the boy recovered.

Reporting this almost miraculous incident in the Journal of Pediatrics, Dr. Nicholson testified that "the treatment resulted in complete recovery without complications in a case which otherwise would have been fatal."

This was the first published report of the efficiency of blood plasma in saving lives and it caused a sensation among clinicians. Research work in blood plasma was started in many laboratories throughout the country. A North Carolina doctor, John Elliott, who advocated using plasma in the treatment of traumatic shock, arranged for a shipment of the processed blood to a South American port and return to prove that neither time nor travel reduced its effectiveness.

Now that it was proven that blood plasma had a definite place in medicine, the problem of processing it in sufficient quantities had to be solved. And here equipment that had been originally designed for another process was found to be the answer to the plasma problem. At this point the doctors working on the plasma realized that, indirectly, one of the world's greatest physicians, Dr. Paul Ehrlich, the man who found a remedy for syphilis, had unknowingly contributed to the drama of plasma. In an obscure paper, Dr. Ehrlich pointed out that biological fluids, as serums, which spoil in their liquid state could be preserved indefinitely if they could be powdered. Laboratory specialists proved Dr. Ehrlich's contention, but the powdering techniques were not widely used until 1930. At that time Dr. William J. Elser, of the Cornell University medical staff, constructed a small pilot plant at the Mulford Biological Laboratories. The drying process was developed by the laboratory's chief, Dr. John Eichel, and two University of Pennsylvania scientists, Dr. Stuart Mudd and Dr. E. W. Flosdorf. The blood serum is frozen and then dehydrated under high vacuum. At first the physicians confined the drying of serums to such blood as was needed to combat specific diseases. But eventually they expanded their program to include the drying of blood for transfusions.

At the Bryn Mawr Hospital Dr. Strumia started operating a small plasma drying plant in 1938. Certain in his own mind that plasma was far superior to serum, Dr. Strumia worked unceasingly to bring his theory before the doctors of the nation and put it to severe tests. While the scientists and physicians were experimenting, world events were proving the need of plasma. During the Spanish Civil War lives were saved with whole blood shipped to the front every day. And in the Russian-Finnish conflict whole blood was used successfully. However, in both these instances the donor supply was close at hand and the problem of shipment and storage did not become too acute. The battlefields of Spain and Finland proved the necessity of front line transfusions, but the disaster of Dunkirk, in May and June, 1940, showed the need for plasma or some similar development. The British Army Medical Corps had placed an elaborate fleet of refrigerated trucks, loaded with whole blood, on the field for emergency transfusions.

But when the Nazi blitzkrieg hit the last British defenses on the Continent, the blood fleet was of little use. The lumbering trucks, like the rest of the material, had to be abandoned by the retreating British Army. Today's war moved too quickly for unwieldy medical equipment.

The lesson of Dunkirk was not lost on the physicians attached to the Army and Navy in the United States. The National Research Council, an organization of technicians, was asked by the Surgeons of the Army and Navy to develop a substitute for whole blood which could be administered under the most trying battle conditions, in all climates, and which presented no transportation or storage problems. Dr. Strumia, as one of the nation's foremost authorities on transfusions, was called in and assigned the task of meeting the armed forces' requirements.

Dried plasma, packed in simple, sturdy crates was Dr. Strumia's answer, but the Navy was skeptical. Maybe dried plasma did work in hospital wards and test cases, but how would it perform in the scalding hell of a submarine hit by depth bombs? So the sea-going physicians of the Navy took plasma to the West Coast and put it through a tough test before they were satisfied, and accepted Dr. Strumia's recommendation.

The military men were not premature in their demands for a whole blood substitute. For even while the Navy was making its tests, the Japanese were preparing their plans for the raid on Pearl Harbor.

At Honolulu, Dr. Forrest Joy Pinkerton wasn't as sure as most of us that the Japanese wouldn't attack the United States. He felt the Nipponese peace protestations were insincere and he said so. More, he reasoned that should war with Japan come, Honolulu and the Parl Harbor naval base were "hot" targets for the enemy bombs. Dr. Pinkerton talked of the dangers of an air raid and started blood plasma banks for such an emergency. The Chamber of Commerce gave him a $4,000 grant to set up a series of frozen blood banks in various points around Honolulu. Dr. Pinkerton suggested the chain of banks so that in event of disaster and some banks were destroyed, a good supply of plasma would still be available from the remaining storage centers. Eventually, the Chamber of Commerce's interest in the project waned and Dr. Pinkerton was forced to complete the program with his own funds.

Then came Pearl Harbor. The Naval Hospital at the base and the Trippler General Hospital were packed beyond capacity with the victims of the Japanese bombing attack. The casualties were unable to get anything more than emergency attention. And the supply of blood plasma was tragically low in both hospitals. But the prophetic foresight of Dr. Pinkerton began to pay off. His trucks trundled in from the ten blood banks and by twilight of that terrible day 700 pints of what had been called "Pinkerton's Folly" had been administered to military and civilian victims of the surprise air raid.

Dr. I. S. Ravdin, of the University of Pennsylvania, was assigned by the Federal Government to fly to Pearl Harbor and investigate the medical phases of the disaster a few hours after the attack occurred. Dr. Ravdin was on the scene as quickly as a Navy plane could get him there and his first-hand report was given considerable attention in the country's medical circles. On his return Dr. Ravdin declared that "due to the farsightedness of Dr. Pinkerton and his civilian committee a large number of lives were saved. Almost every casualty needed blood plasma to revive him from the shock brought on by terrible wounds, burns or loss of blood, and to strengthen him for the ordeal in the operating theater. One hesitates to think what might have happened had not all that plasma been made available immediately."

With the United States now in the most bloody war in all history, the Red Cross realized that some system must be organized and set up for the collection of blood from volunteer donors. Bleeding stations were opened in three cities—New York, Philadelphia, and Baltimore—and as the Army and Navy increased their plasma requirements, additional stations were set up across the nation. Since the blood donated must be processed within 72 hours after it is collected, pharmaceutical plants other than the one at Philadelphia were given processing contracts. These plants were located as near as possible to the various bleeding stations.

In order to keep the armed forces supplied with a sufficient quantity of plasma, an intensified campaign has been conducted to enroll donors. It can be seen that in a project of such size an assembly line type of production had to be introduced in the blood centers. In a paper written for the American Medical Journal, Dr. Earl S. Taylor, Red Cross Blood Donor Service Technical Consultant, outlines the procedure established for the collection of the vital fluid. No extensive physical examination is given, but the volunteer donor is asked a series of questions that will tend to establish his general physical condition. Temperature, hemoglobin, blood pressure and pulse determinations are made and it is on the basis of these, together with the informal history, that the physician in charge determines whether or not the donor is acceptable.

Blood taken from donors is placed in pint bottles, packed in refrigerated boxes and shipped to the nearest biological laboratory for processing. At the laboratory it is poured into a large centrifuge and spun at high speed until the red and white corpuscles have been whirled to the bottom of the vat and the plasma, a colorless fluid, has risen to the top. The plasma is then drawn off and placed in vacuum sealed bottles and frozen. The next step is to take the frozen plasma and place it under high vacuum for dehydration. With all the water extracted from the plasma, it takes on a golden color and is light and flaky. The dried plasma is divided into pints, placed in a carton with a pint of sterile water with which it must be mixed when needed, and then both containers sealed in tin cans along with the rubber tubes and transfusion needles that are necessary to complete the operation.

Under Dr. Strumia's system this plasma will remain effective for years under every climatic condition. Mix the plasma with the sterile water for two minutes, inject the fluid into the patient's veins and the life-giving force will immediately raise the blood pressure, help stave off infection and give the dying human a new, better chance to survive.

The conditions under which the plasma is administered have no effect on its vital force, either. Major General Albert W. Kenner, executive officer of the Surgeon General's Office, who directed the Army medical operations during the African campaign, says that "it is common for plasma to be given in a foxhole or a slit trench at the front lines." General Kenner points out that the increased range of artillery fire and the dangers from aerial bombings has made it necessary to remove evacuation hospitals farther behind the lines than in the last war and this places greater emphasis on the surgical truck that can move up to the front and on emergency medical treatment that can be administered under fire.

In a statement, General Kenner said:

"These (surgical) trucks carry large supplies of plasma. But after the first transfusion a wounded man often has to spend 10 to 12 hours in an ambulance to reach the hospital. He is given additional blood plasma injections during the trip so that he will be in a fairly strong condition upon arrival and can generally be operated upon at once. About 97 or 98 per cent of the men reaching an evacuation hospital live today as compared with only 88 per cent in the last war. This is due largely to plasma."

According to this medical officer's estimate about 30 men in every hundred wounded require plasma injections, not once, but from six to ten times each. This means that six to ten persons on the home front must donate a pint of blood each to save one soldier's life.

That plasma cannot be underestimated as a life-giving fluid is evident in the reports from military doctors serving on the front lines and from the testimony of the soldiers and sailors themselves, who know that many have won a new lease on life only because plasma—in sufficient quantities—was available to them when they were wounded.

A few case histories from the files of the Red Cross might underscore the importance of plasma in this war. For example, there is Private Harold Peters, USMC, of Holmesburg, Pennsylvania. Peters was in the Tarawa invasion and, for three days, was successful in dodging Japanese gunfire. Then, as he puts it, "three hunks of shrapnel" hit him. In an interview at Red Cross headquarters Peters said, "They didn't bother me much because I guess I didn't have time to notice them. Then on the ninth day on the island, I noticed something wrong. It was filiariasis. Filiariasis is a form of elephantiasis, caused by mosquito bite. It causes painful swellings on various parts of the body. It is one of the tropical diseases for which our research doctors are trying to find a permanent cure. When I was taken aboard ship, the shrapnel was removed and I was given a gallon of plasma. You see, I'd had malaria sixteen or seventeen times, and with that filiariasis, and the shrapnel wounds, I was worse off, I guess, than I thought I was. Well, I pulled through. My luck really began when sixteen people, unknown to me, gave their blood long before the Tarawa invasion. If it hadn't been for them, I guess I'd still be at Tarawa—in one of those hastily dug graves."

In a letter to a friend, Lieutenant Thomas E. Crawford, of Burlington, New Jersey, tells of an incident during one phase of the South Pacific campaign that indicates the conditions under which the plasma can be administered. He writes:

"Plasma is one of the finest developments of this war. It is impossible to praise it too highly. My outfit has administered it quite frequently and I have seen results obtained by its use that are almost miraculous. The boys have given it under the most adverse conditions while under fire. I have actually seen it administered to a casualty by a four-man litter squad evacuating a patient over a jungle trail. Two men were carrying the litter, the third walking alongside holding the bottle of plasma overhead so it would flow into the wounded man's veins. The fourth member of the litter crew was 'Johnnie-on-the-spot,' trailing his companions by about fifteen yards, carrying a submachine gun on the alert for two Japs who had been trailing the party through the jungles. Those boys evacuated that patient five miles and then almost collapsed when they reached their destination. They had given the casualty three units of plasma during the perilous trek. The doctors at the aid station said the man would recover due to their courage and the blood transfusions. I'm telling you this so you will know just how valuable the efforts of the blood donors is considered down here."

And then there is the story told by a Navy nurse, one of the first to land in the South Pacific. Lieutenant (j.g.) Mary Gresko, U.S.N.N.C., says one of her first duties was to instruct the hospital corpsmen how to prepare and administer blood plasma. They had to give it on the field, under fire, and there just couldn't be any slip-ups.

"Out there," said Lieutenant Gresko, "we used plasma all the time. We gave it like you would give a thirsty man a drink of water. Especially we used it in burn cases and there were so many of these.

"There was one boy none of us will forget. He was a young aviator—just twenty-three. He made a forced landing after a Jap pilot had shot his plane to bits. None of us will ever know how he managed to land that ship. When he was pulled out of that plane no one would have recognized him as a human being, he was so badly burned.

"Burn cases suffer agonies for months, but this boy was worse off than any I ever saw. When you change the dressings on burned patients they suffer terribly; but never once, in all the time I was there, did that boy complain. We believed he would live only a few weeks at the most, but not long ago I had a post card from him, written with his own hands, after we had thought he had lost the use of his hands forever. This boy is alive today and on the road to nearly complete recovery only because of two things—his courage and blood plasma. He must have received at least 100 pints of blood during his stay at the base hospital. Later, of course, he was able to have whole blood transfusions. But during those first few weeks it was the blood from the home front—blood plasma—that kept that boy alive." What a necessity plasma is!

However, even with the wholehearted support of the home front volunteer donors there is still not enough plasma to meet the needs of the armed forces if the fighting continues. At Harvard Medical School, Dr. E. J. Cohn hopes to reduce plasma to some small form that will speed its efficiency. The fluid carries minute fragments of a protein known as albumin. This is the element that attracts water from the body tissues into the blood vessels. Dr. Cohn contends that if the albumin can be separated from the plasma, a small quantity would be sufficient to support a battle casualty until additional medical treatment could be given. Last January, Dr. Cohn collected a large quantity of albumin from a selected group of donors and presented it to the Army and Navy medical authorities for tests.

The albumin was injected into the veins of wounded men and the results were heartening. The two blood specialists of the Army and Navy collaborated on a paper published in the United States Naval Bulletin which explained the albumin experiment in detail. These men, Captain D. B. Kendrick, of the Army, and Lieutenant Commander L. R. Newhouser, of the Navy, said that the injection of this new element had just about the results Dr. Cohn had foreseen. They said their tests indicated that 100 cc. of albumin restored blood pressure and fought off infection as well as five times that amount of plasma and about nine times that amount of whole blood.

Declaring that albumin can be packed in even smaller cartons than plasma, an important factor when shipping space is limited, the specialists said albumin "is of tremendous importance to our military forces in that it may provide a method of restoring circulating blood volume among casualties in landing parties, among parachute troops, and to other casualties in places where the standard package of plasma cannot be made available."

Should albumin prove itself through the additional tests planned for it, it is possible that every man in the combat forces will be equipped with a small vial of the substance and a tiny needle. When wounded he, or someone near him, can administer the blood protein with about the same ease lay diabetics give self-injections of insulin. The albumin would sustain the casualty until further medical treatment could be given.

Clinicians are hopeful of albumin for another reason. They hope that, should it prove its effectiveness, the necessity of blood donors will disappear. For they believe that albumin drawn from the blood of cattle will be an effective substitute for human blood.

American physicians are not the only medical men anxious to develop some kind of practical blood substance, or substitute, that will enable them to save the lives of battle casualties now, and victims of peace-time disasters later. The British armed forces use dried plasma, liquid plasma and some dried serum. The Army maintains a Blood Transfusion Service which enrolls volunteer donors from the armed forces while the Ministry of Health operates a similar service for civilians. The techniques used in drying the blood are vastly different from those used in the United States. The original technical staff was drawn from the Royal College of Surgeons and the Middlesex Hospital. Both the French and Norwegian campaigns were supplied with transfusion equipment by air service and fleets of refrigerated trucks.

In Russia the nationwide blood transfusion system was organized in Moscow in 1926 under the direction of Lieutenant Colonel Andre Arkadievich Bagdasarov, the international authority on transfusions. During the border warfare with Japan in 1939 and in the war with Finland in 1940 and 1941, Colonel Bagdasarov directed blood injection activities of the Red Army, often supervising transfusions at the front lines while under heavy fire.

The Soviet blood donor system resembles, in most respects, the system carried on in this country. There are about 1,500 bleeding centers and it is estimated that an average of 2,000 persons a day donate blood in Moscow alone. However, the average individual donation ranges from 225 cc. to 450 cc. per person as compared to the 500 cc. in the United States. About 95 per cent of the Russian donors are women, whereas in this country the female volunteers number about 50 per cent of the donors. Since food is so scarce, Russian donors are granted extra rations as an inducement to aid the soldiers in the Red Army.

Whole blood of the universal type "O" is used for most battlefield transfusions, and, in addition, large supplies of type-specific plasma are used. Recently the Union of Red Cross and the Red Crescent Societies of the USSR asked the assistance of the American Red Cross in obtaining plasma-drying equipment.

Under the direction of the government-controlled Central Institute on Experimental Hematology at Moscow, the whole blood or plasma is flown each day to distribution centers behind the front lines. From these points it is distributed to medical stations under the direction of sector surgeons. The type "O" blood is shipped in 1,000 cc. thermos bottles and 200 cc. ampules. The ampules are carried by medical workers in the front lines and are administered under the same conditions the American Army uses dried plasma.

The blood procurement program in China is too recently organized to enable us to get a clear picture of its procedures. Although Dr. Norman Bethune showed the value of blood transfusions to the Chinese military authorities before his death in China, no organized blood procurement administration was set up until the training of the necessary technical personnel had been undertaken by the American Bureau for Medical Aid to China. This organization opened a special blood donor center in New York's Chinatown to aid its training program.

In October, 1943, a small group of men and women made the long and hazardous trip to China to establish a blood transfusion system. They centered their operations in Changsha under the supervision of the military commandant of the Ninth War Area, who accepted the responsibility of recruiting donors. The original group, trained in Manhattan's Chinatown, also served as a "pilot unit" on the field, training additional personnel so that other bleeding centers could be opened throughout China. Whole blood and dried plasma is used. Generalissimo Chiang Kai-shek obtained the necessary plasma-drying equipment from this country under Lend-Lease.

In the civilian program of blood supply in Nazi Germany only "Aryan" blood was accepted and the donors were paid ten marks for the first 100 cc., and five marks for each additional hundred. However, when the need for blood increased with the mounting German casualties on all fronts, rumors had the Germans taking blood from women and children in the Nazi-occupied countries. The Greek Information Service accuses the Hitler medical men of supplying their blood banks with the life fluid of Greek women, while the Russians say blood was taken from even the youngest Russian child in captured villages.

It is also reported that the Germans used various synthetic blood substitutes, but the information on these products is vague. They are reported to range from periston, and iron-hemin compound which was not too successful when tried in this country, to an I.G. Farben synthetic that is described as "effective," but whose formula has been a closely guarded secret.

While the information on the blood procurement program in Nazi Germany is far from complete, the data on its ally, Japan, is even more vague. Japanese radio propaganda is reported never to make an appeal for blood donors. Newspaper stories and scraps of information picked up from such sources as prisoners of war, refugees from occupied areas, and intelligence reports indicate that no such blood procurement exists. It is believed that the Japanese rely on whole blood transfusions, even under combat conditions, when such treatment is necessary.

Up to the time of the Fascist Government's collapse in Italy there had been no large scale blood procurement system established despite the length of time the Italian legions had been engaged in hostilities with various minor nations. An American aviator, forced down in Italian territory shortly before the Yanks invaded the country, reported that he had been taken to an Italian hospital where he received saline-glucose infusions under circumstances which would probably have called for plasma, serum, or whole blood in this country.

It is difficult to draw conclusions on the comparative value of the various blood donor programs used by various countries because of the limited information available. However, it is quickly apparent that the Allies' blood systems as they function behind the lines are superior to those programs supplying blood to the Axis forces.

When comparing the programs used by the Allies consideration must be given to various factors, among them: size of armies involved, available population sources, distribution problems, and the distance of the home front from the battle lines. America's Army and Navy, fighting in almost every corner of the world, are protected by the American program far better than they would be by those used in other countries. Dried plasma can go anywhere, keep indefinitely, and is procurable in such quantities that it can be supplied in sufficient amounts to numerous battle zones, ready for use at any time.

The Russians, still within easy flying distance of a front that, at one time, was less than twenty miles from Moscow, can use whole blood in great quantities, for the problem of distribution is fairly simple. And the donor supply is easily accessible. The British, on the other hand, did have their forces scattered around the globe to a small extent, and their blood supply was augmented by programs in various parts of the Empire. Thus, they adopted a program best suited to their problem of supply and distribution.

The failure of the Axis countries to develop a fuller blood transfusion program may be laid to two reasons, according to American military physicians. First, there is the lack of necessary technical equipment and, secondly, the greater part of the research and development in the field took place in America before the outbreak of the war. Then it is pointed out that the current failure to maintain a blood donor system may be due, in a large measure, to the American and RAF bombings of large German and Japanese cities—the normal source of the necessary blood supply.

The experiments with human blood since Pearl Harbor have not been limited to exploring its battle-front possibilities. Over the past year the blood donated by civilian volunteers has enabled the scientists to develop a variety of life-saving and disease-fighting techniques for the benefit of the civilian in the post-war world. Before Pearl Harbor, the amount of blood donated was insufficient for the technicians to determine whether or not plasma's basic parts had any uses other than its original purpose. However, more than twelve million pints of blood have been donated since February, 1941, and a certain amount of this has been turned over to the laboratories for experimental purposes.

The results came in the form of three great contributions to the medical profession. The first was a successful anti-serum blood plasma whipped into a foam, which is considered invaluable in delicate operations. The second contribution was a fool-proof serum for determining the type of blood to be used in various transfusions. The third, and perhaps the most widely accepted of these developments, is the measles anti-serum. Known professionally as *gamma globulin,* it is produced in a coarse, powdery form. This white powder is mixed in a salt solution and injected into the individual exposed to measles. This new and effective method of measles control was developed by the country's outstanding medical scientists carrying on the research projects for the Preventive Medicine Service of the Office of the Surgeon General of the U. S. Army. The preliminary work on measles was conducted by Dr. Edwin J. Cohn, at the Harvard Medical School. Dr. Cohn succeeded in breaking blood plasma into seven fractions. The three developments mentioned use only four of the seven known proteins which Dr. Cohn discovered to be ingredients of blood plasma. One of these is the *gamma globulin* which, research showed, contains all of the so-called antibodies in the blood. These antibodies are the chemical factors which tend to establish an individual's immunity after he has suffered from a particular contagious disease. It is explained that a person who has contracted measles does not, generally speaking, contract a second attack because his blood now contains the antibodies to fight off the infection.

Blood donated through the Red Cross bleeding stations comes from thousands of persons who have established immunity against innumerable contagious diseases, including typhoid fever, scarlet fever, diphtheria and others, as well as measles. Thus far, however, the technicians have concerned themselves only with investigating the use of *gamma globulin* as a measles preventive.

Studies conducted by physicians have resulted in the accumulation of data on more than one thousand persons. Much of the measles study was carried on in Army camps in the Eastern States, but one significant study was made at an Eastern college where a mild measles epidemic was reported among the girl students. *Gamma globulin* was administered to 67 exposed students who had no previous measles history and who, therefore, were susceptible to the disease. It was not injected in 38 other susceptible students.

In the group treated with *gamma globulin,* only one case of "average measles" developed. There were three cases of "modified measles" and eight cases of "mild measles." Among the 38 girls not treated with the *gamma globulin* solution, 18 developed "average measles" and five contracted "mild measles."

Until Dr. Cohn was successful in separating the *gamma globulin* fraction from blood plasma, measles was treated by injecting an extract made from human placenta. Medical men, however, describe this method as not too effective. Reports say it often caused strong and unpleasant reactions in the patient. *Gamma globulin* is reported to be non-toxic and have little or no after-effect. While most of the product has been used for inoculation of men and women in the armed forces, the scientists report that this new anti-serum, a by-product of human blood, is most effective on children under two years old. Dr. F. F. Johnson, head of the blood fractionation department at Cutter Pharmaceutical Laboratories at Berkeley, California, the principal producer of *gamma globulin,* says there is enough of the anti-serum on hand now to release small quantities to civilians through the state public health services.

From the standpoint of the national war effort, the manufacturing of the human surgical sponges are the most important of the new blood products. These sponges are made by whipping two blood components, fibrinogen and thrombin, to a heavy foam or froth in a machine which closely resembles a milk shake mixer. The result is a blood meringue which is frozen, then dried in an oven which "draws" out the moisture by a vacuum process rather than by heat. The construction of this oven and its method of operation is a closely guarded military secret.

These blood sponges are considered of great value because, unlike the usual medical gauze surgical sponge, they can be stitched right into the soldier's wound and, eventually, will dissolve and be carried off in the blood stream. So successful has been this particular blood by-product in military surgical cases that even conservative surgeons are predicting that it will revolutionize delicate surgical techniques. Its ability to clot blood and stop bleeding in a short time is considered of great importance, especially in brain operations. While all production was routed to the armed forces, Dr. Johnson believes that its use will be almost universal after the war.

A highly successful by-product is the best workable serum yet developed for the typing of human blood. The blood of all individuals must be typed before a transfusion where whole blood is necessary. This whole blood falls into four general types, with one, the so-called "O" type, being the only classification that can be used on all patients requiring transfusions.

The new, potent serum is called *isohemagglutinin* and it is considered fool-proof in typing human blood. The Cutter Laboratories started production on *isohemagglutinin* in the fall of 1944. Its entire production is now being utilized by the Navy.

Cutter is the largest plasma processor on the West Coast and one of the largest in the country. Just how much it handles is a closely guarded secret, but the Red Cross in the section reports 1,475,000 pints will have been collected by the end of 1945. With the exception of a laboratory in Los Angeles, which processes a comparatively small quantity, the rest has passed through the Cutter plant.

The technicians at the Cutter plant say that the quantity of blood from donors will, of course, fall off after the war. The Red Cross bleeding stations are now crowded with persons who know they are contributing to a vital phase of the war effort. After the war, the giving of blood will, in all probability, return to its semi-commercial status. Pre-war prices for blood donations ranged from $75 a pint in special cases to about five dollars a pint for routine bleedings from professional donors. Medical men believe that post-war prices will be lower, because the public has lost its fear of blood donations and the ranks of the professional donors will be increased.

The plasma fractionation program was first developed on a large, practical scale by Dr. Cohn after he had been requested by the National Research Council to conduct experiments to learn if beef plasma could be substituted for human. His first success was in the separation of albumin. Later he isolated the other six plasma fractions—*fibrinogen, thrombin, gamma globulin, alpha* and *beta globulin* and *isohemagglutinin.*

The process of isolation of the fractions, as practiced by the Cutter Laboratories, follows the Cohn original procedure. The whole blood is whirled in a centrifuge to drain off the red cells. The residue, or plasma, is then put through a series of vats, each filled with various degrees of alcohol, acid, alkaline and salts to draw off each individual fraction. The temperature in each vat also varies. Each blood by-product thus obtained is dried by vacuum. This process is called Lyophilization and enables dried products to be transferred back into solutions without any chemical or biological change.

At present the red corpuscles of the human blood are the only waste matter. But experiments, extensive tests, are now being carried on to determine whether or not these corpuscles can be used in the treatment of anemia. Some limited use of the red cells as antiseptic dressings for war wounds have been reported.

Of the remaining plasma ingredients, alpha and beta globulin are the only two for which some use, however limited, has not been found. But the Harvard Medical School reports that Dr. Cohn is testing them now for possible immediate benefits to wounded soldiers and sailors and for civilian use when peace comes.

8. War on Malaria

LIEUTENANT COLONEL Arthur F. Fischer was one of the 20,000 American and Filipino troops stricken with malaria in those last days before the fall of Bataan. He had just been informed by an army nurse that there was no more quinine to be had.

For twenty years, as head of the Philippine Bureau of Forestry, Lieutenant Colonel Fischer had butted his head against the stone wall of official indifference in Manila and Washington, trying to make the government see the importance of an American source of quinine. But a small experimental grove of the cinchona trees, on Mindanao Island, was all that he had to show for his long campaign. That grove was 600 miles south of besieged Bataan.

A man who has fought for twenty years for one thing isn't the kind to give up even in the face of what would seem to be total defeat. For five days he lay sweating and shivering through his malarial chills and fever. On the sixth, he scrawled a note to General Wainwright. He knew of a source of quinine, he wrote, and if the general would let him go to Mindanao, 600 miles to the south, he felt sure that he could get some back to Bataan.

Wainwright acted immediately. With malaria felling as much as 85 per cent of some units, any amount of the drug would be a godsend. He heard the rest of the story of Fischer's quinine grove as they thrashed out plans for getting the quinine to Bataan.

In 1921, Fischer explained, one of his foresters had died from malaria for lack of quinine. It had been scarce at that time, too, but even worse, what was available was far too expensive for the average native of the East to buy. He had reported the incident to General Leonard Wood, then High Commissioner of the Philippines, and Wood had given him permission to plant the experimental grove on Mindanao.

That was only half the fight. Finding cinchona seed to plant had been even more difficult. The high-yield seed that the Dutch had perfected was jealously guarded by them. Finally, he located a Java planter, suffering from an aggravated case of financial embarrassment, who was persuaded to sell a package of seed for 4,000 pesos. A British sea captain carried on from there and smuggled the precious seed out in a Horlick malted milk bottle.

In spite of the fact that the natural conditions of Mindanao were perfect for growing the cinchona trees, Fischer ran into one difficulty after another. Before the seedlings could be transplanted from the seedbed, he lost half of them to a fungus disease. And when the small trees were set out in the forest they were almost immediately attacked by an army of voracious forest cockroaches. Attendants had to go out by night by lantern light and hand pick them off the young trees. Right on the heels of the cockroach debauch came a drought and for weeks the grove was kept alive only by laborious hand watering. Finally, the water hole, the only source of irrigation available, dried up, and the plants started wilting by the thousands. An appeal to the Philippine Malaria Control Board for a small reservoir as a protection against future droughts evoked only the stupidity of this reply: Cinchona cultivation, the board held, was not considered malaria control work.

In 1927 the first bark was harvested and processed. Its quinine content was as high as that of the original Ledgeriana cinchona from Java. With this to go on, Fischer proceeded to talk the government into letting him set up a pilot plant in Manila for processing totaquina, a crude and inexpensive extract.

The pilot plant was in Japanese hands now, but, Fischer explained, the Mindanao grove was still intact and ready for harvest. If Wainwright could get him down there, he could grind the bark to powder and get it back to Bataan. Then it could be brewed and drunk like tea. It would at least check the ravages of the disease.

At two-thirty the next morning, March 28, twelve days before Bataan fell, a rickety old Bellanca commercial plane took Fischer off from Bataan and headed south. They made a fine pair. The ancient Bellanca with a top speed of 90 miles an hour skulked down the valleys and behind mountains to avoid enemy airmen. To get across stretches of open water it skimmed so low that it was barely out of the reach of the whitecaps. And the man who had attempted the almost futile job of getting quinine in for the defenders of Bataan was in a rocky condition himself. Malaria had wasted him from a normal 150 pounds to 96; blood poisoning had set in in his left arm and only the last grains of quinine on Bataan and a huge dose of vitamins held him together.

The first day in Mandanao he was not able to leave his bed. But on the second day he summoned enough strength to get up and explain to his old foresters, who had gathered around, his plans for getting the powdered bark out. Most of them had worked with him since he had first come to the islands in 1912, direct from the School of Forestry at Yale. They were all Filipino boys and only a few of them were left, but they did a man-sized job of bringing in the bark. As fast as they brought it in, Fischer and another boy put it through a corn grinder, the only machine they could find for the job, and ground and re-ground it to powder.

To hold the red-brown powder, Fischer located 275 empty oil drums. The oil residue was burned out of them with dried grass and then they were scoured till they shone. Carpenters completed the containers by making wooden lids for them sealed tight with gaskets of old inner tubes.

In spite of these makeshifts and his own weakness from the fever that still plagued him, Fischer was well on the way to having a good supply of the crudely ground powder ready for shipping by the end of the first week. Then, on Easter Sunday, April fifth, he got bad news from Wainwright: it was no longer possible to get ships into Bataan; could he extract the quinine from the bark and get it in by air?

Maybe he could refine quinine from ground up cinchona bark; but he'd have to have chemists and raw materials. There'd have to be lime, sulphuric acid, ether, to name the most essential.

Fischer looked up an old friend of his on the island—a priest who ran a school on the coast. The good father put the facilities of the school's laboratory at his disposal;

hunted up a missionary who had been a pharmaceutical chemist before taking the cloth and an American who twenty years before had earned a Ph.D. in chemistry but hadn't been near a test tube since.

Then Fischer started scouring the island from stem to stern for raw materials. He found a half dozen demijohns of sulphuric acid in an old mine shaft; a few drums of ether were dug out of the supply room of a hospital; boatmen were sent to the lime pits of a nearby island; and from a Chinese soap factory on the coast he came up with a small amount of sodium hydroxide. With the raw materials on hand, the next job was locating equipment. First, an agitator would be needed for mixing. It had to be a special kind, a stainless steel one. Miraculously, one was discovered in the remains of a wrecked pineapple cannery. For mixing vats, old plantations were ransacked of their bathtubs.

He set up his plant deep in the forest, in a spot not likely to be discovered were the enemy to make an invasion. But he was still in the process of assembling all his material and equipment when the word came: Bataan had fallen on April ninth. With Bataan had gone the Philippines. Soon the Japanese would move into Mindanao and with the island would go the last Allied source of Ledgeriana cinchona trees.

Fischer had his orders from General Wainwright to report to a secret airfield and there await a plane that would take him to Australia. But before he left, he went to the grove and hand-picked a few ounces of cinchona seeds. He spent his last afternoon and night picking and drying the seeds. Then, before he left the next morning, he packed them carefully. Cinchona seeds won't keep very long unless they are packed in air and moisture-proof containers. And these seeds had to last long enough to be planted in the Americas. So Fischer turned the hospital upside down, looking for something to hold his future quinine grove. Finally he found two condensed milk cans that could be telescoped together. The seeds went into the inner tin; that was fitted into the larger can, which he had carefully insulated with dried grass and moss and a lid clamped tightly down.

Then the long trip home was begun. From the grove Fischer went by car the thirty miles to the airport. The air was full of enemy planes and a Filipino corporal was strapped to the running board of the car to act as lookout so that they could make for a ditch at the first sign of Zeros. The trip to Darwin was made in one of the last American bombers to leave the Philippines and, five days after landing at Darwin, Fischer left Australia on War Department orders on board the liner Coolidge.

The Coolidge made the United States in seventeen short days. But it was time enough for Fischer to gain back half of his fever-wasted weight and to tend to the cinchona seeds. On landing, he turned them over to the Department of Agriculture to be flown to the Glen Dale, Maryland, station for immediate planting in seed flats.

Colonel Fischer himself was assigned to work with the Board of Economic Warfare in the establishment of cinchona plantations. By 1943 he was setting out foot-high healthy saplings on the foggy hillsides of a ten-thousand-acre plantation in Costa Rica. Only two per cent of the Mindanao seed had failed to sprout.

By next year, it is estimated, the Fischer cinchona Ledgeriana groves in Costa Rica will be harvested to the tune of 10,000 ounces of quinine. It's going to come in handy in the gigantic task ahead of us. In practically every nation there will be a need for it. China alone needs more than the world's entire supply in order to check the disease, which is spreading so rapidly that, if it isn't checked soon, the Japanese will be able to sit back and let mosquitoes do their fighting.

Even as Bataan fell before the twin assaults of the Japanese and the even smaller but no less deadly Anopheles mosquito, the United States, so lackadaisical in prewar times about American sources of the best malaria therapeutic, began making frantic efforts to round up every last grain of quinine that it could. One of the first steps was a WPB call upon all the druggists in the country to turn in their stocks of the drug. The next step was a desperate combing of the jungles and mountainsides of Central and South America to uncover the remnants of the wild cinchona trees which up to the nineteenth century had made the Latin Americas the world's foremost producers of the "fever bark."

As far back as 1638 the therapeutic value of the bark of the tall, evergreen trees had been known. The story goes that the Countess of Chinchon, wife of the Governor of Peru, ailing with fever, was persuaded by her good friend, the Corregidor of Loxa, to sip some tea made from the boiled bark. It worked so well that the countess praised its merits extravagantly, and its use spread. The Jesuits carried on from there, and they were so active in introducing it into Europe that for years it went by the name "Jesuit's bark."

There was little effort made to cultivate the trees in Latin America. True, some small man-made orchards of the cinchona were started, but on the whole the work of harvesting the bark was left to certain Indians, "cascarilleros," who searched the higher plateaus of Bolivia, Peru, Ecuador, Colombia and Venezuela. Then, as now, the "cascarilleros" used bone-bladed knives to strip the bark, for the alkaloid content of the trees soon eats away steel. No attempts at replacement were made and the most valuable of the trees were quickly destroyed. Nobody but the British and Dutch seemed to be foresighted enough to foresee an end to the medical bonanza; immigrant traders were profiting outrageously and even before our own Revolution was ended the demand had far outstripped that of the wilderness supply.

Both the British and Dutch saw in the cinchona crops a chance to make a fortune, and to make it on hitherto unused Javanese and Indian mountainsides too steep and rainy to accommodate any other crops. The first importations of South American cinchona seeds to Java were made in 1852 by John Markham, to collect seed for plantings in India. But the India plantings petered out in a few years, because of a fall in prices. Markham had been assisted by Charles Ledger, an Englishman who had lived in Peru and Bolivia for twenty years and knew the jungles like a book. In the latter country he had concentrated on gathering the seed only from trees of superior yield, and this seed he had shipped to Java. It was the stock for the more than 50,000 acres of Ledger cinchona trees, which before Pearl Harbor provided 97 per cent of the world's quinine—supplied it through the greedy hands of the Kina Bureau of Java and Amsterdam, the most fabulously successful monopoly ever known.

In the meantime, South American production of the drug had fallen off almost completely. That continent's output simply could not stay in the market with the efficient and skillful cultivation of the Dutch. Colombia's production alone, which as late as 1880 had been the largest in the world, totaling six million pounds of bark as against a paltry 70,000 pounds from Java, sank to a mere 35,000 pounds by 1911. Java's on the other hand had soared to 20 million pounds. By 1938, however, the Latin American production of cinchona was beginning to increase again, totaling about seven and a half per cent of the world's supply. And luckily, just before the Dutch East Indies fell to Japan, the U. S. had purchased enough Java cinchona to make 6,000,000 ounces of refined quinine sulphate. The other United Nations, unfortunately, had not been even that foresighted and our Java purchases gave the United States a corner on the Allied quinine market.

The war, however, is being fought in all the pest holes of the world, and this stock of quinine goes almost entirely to our armed forces. Quinine sulphate is gone from the civilian drug counters and if quinine is required it can be had only on a doctor's prescription. Even at that, quinine sulphate is not used: the crude and inexpensive extract of cinchona, totaquina, which Fischer made in his Manila plant for the poverty-stricken natives of the East, is substituted.

The search for wild cinchona trees and large scale cultivated plantings in South and Central America, such as the 10,000 acres of Costa Rican hillsides set out with Fischer's seedlings, brought the Latin output of quinine up to 149,000 pounds, an amount that increases steadily by the week and month.

This upsets the Kina Bureau as a world's quinine cartel for ever and a day. Even if the South American crop is never, as planters and governments of that continent hope, a durable Pan-American crop, it will act at least as a formidable weapon in keeping Java prices down. But the chances are that the postwar demand for the drug will far exceed even the output of both sources. It is good news, therefore, that for the first time in almost a half century the Western Hemisphere will not have to depend on the fortunes of war in the Far East for the one specific that does more than any other in allaying the fever that is endemic in seventeen of our own states and in all the countries of South America north of the Rio Plata.

That we will ever permit the South American cinchona harvest to lapse into unproductive wildness again is unthinkable. Quinine cannot be produced overnight or even in a season. The trees are propagated from seeds so tiny that it requires 75,000 of them to make up an ounce. After a nursery period of from six to ten months, during which time the most painstaking care must be exercised in "hardening" the plants to light, they are budgrafted in the same manner as fruit trees. When they are about a year old they can then be set out in their permanent location.

The trees grow best at altitudes from 5,000 to 10,000 feet on forested slopes where nature has laid down a thick blanket of old leaves and humus. In their fourth or fifth year the trees put forth their lilac-like blossoms and are ready for the harvest. This is essentially a matter of selective logging. Badly started trees are selected first—an average of one-fourth of the stand—and the thinning is made up by new plantings. An average yield from mature trees is about eight tons of bark per acre, or roughly 16,000 ounces of effective malaria relief. At the end of fifteen to thirty years all the original trees have been cut over.

While the druggists of America were sending in their stocks of quinine to the WPB or giving them gratuitously to the Red Cross, the scientists of the nation were busily engaged in research for a substitute malarial remedy. Quinine, though holding top place as the malarial relief, is actually not a true preventive of the disease. It helps destroy within the blood the schizonts or asexual forms of the parasite injected into the human system by the Anopheles mosquito, and thus relieves the patient from the fever attacks. It also destroys the gametophyte or sexual forms of the parasite, which transmit the disease through the agency of the infected mosquitoes. And though literally thousands of drugs have been tested both before and during the quinine crisis none of them does any more, or does the job as effectively as quinine.

Atabrine, a synthetically created substitute developed in Germany before the war, was one of the drugs brought forward both as a preventive and a "cure." It does work to postpone the appearance of the symptoms and keep down non-effectiveness from malaria even though men are bitten by infected mosquitoes. But, as in the case of the sulfa drugs, there are a good many men whose systems will not tolerate atabrine, and there have been instances of large groups of patients becoming ill and turning a violent yellow because of this intolerance. As for plasmochin, also a synthetic, tests indicate that it helps greatly in stopping the spread of the disease, but lacks the curative powers of quinine.

In the development and refinement of these drugs, human guinea pigs played an important part. They were men, and sometimes women, possessing an unusual, but heroic brand of courage, and they came from prisons, conscientious objectors' camps, nursing staffs and even the Army.

One of the most interesting of these experiments on the worthiness of atabrine took place in New Guinea, which, incidentally, proved to be one of the nastier plague spots of the war. (One infantry division there, going into enemy-held territory in the early part of the campaign, reported

6,000 cases of malaria in 60 days.) One hundred and fifty G.I.'s stationed in New Guinea volunteered to go back into the jungle and acquire malaria. Split into three groups, a third took daily doses of atabrine; another third took another drug and the remaining fifty just let the mosquitoes bite them without taking any preventives at all.

Most of the last group came down with malaria, but only one of the atabrine group was afflicted. No figures were given for the third except that it had proved disappointing to the Army doctors and not half as effective as atabrine.

One of the most recent additions to the list of quinine substitutes is synthetic quinine produced chemically from coal tar, evolved by two young Harvard scientists, Drs. William E. Doering and Robert B. Woodwar. One hundred years ago a German—Strecker—determined that the quinine molecule consists of 24 hydrogen, 20 carbon, 2 oxygen and 2 nitrogen atoms. From that time on scientists, including the famed Pasteur, made various futile attempts to use this structure in building up quinine from a source other than cinchona. Where the others had failed over the period of a century, the two Harvard men succeeded in fourteen months. The development of synthetic quinine, constituting as it does the greatest threat to any revival of the Java quinine cartel, marks the second time that quinine research has smashed a monopoly. In 1856 a seventeen-year-old chemical prodigy, William Perkin, tried to synthesize the drug. He had a notion it might be made from aniline, a by-product of coal tar, but all he got was a black residue. In disgust, one day, he poured alcohol into a beaker of the stuff to wash it out—and a beautiful purple-blue appeared. That color turned out to be mauve, Perkin's mauve, the first of the coal tar dyes. It made a fortune for its discoverer and within a few years had almost obliterated the vast indigo and madder plantations of India.

Doering and Woodward worked with the same stuff Perkins used, coal tar, the sticky black substance left over after coke is made from coal. First reports on the synthetic quinine say that it is quite probable that the synthesis may prove better than quinine obtained from cinchona.

About the time that the rank and file of the U. S. Army learned the sad difference between traditionally romantic Pacific islands and the site of Lever Brothers' plantations in New Guinea and the Solomons, the Office of the Surgeon General, U.S.A., issued something new in the way of field manuals. It was a small, 36-page, pocket-sized booklet, tagged officially A.G. 300.7, but regarded unofficially as one of the most sprightly ever issued by the Government Printing Office. It was written by Major W. Monroe Leaf, who was something of a celebrity in 1936 because of his children's book entitled "Ferdinand the Bull." Twenty of its 36 pages were illustrated with the drawings of Captain Theodore Seuss Geisel, whom the Army associated with the Special Services Division but who many will recall as the famous bug cartoonist "Dr. Seuss." A.G. 300.7 went something like this:

This is Ann. She's dying to meet you.

Ann really gets around. Her full name is Anopheles Mosquito and her trade is dishing out malaria. She's at home in Africa, the Caribbean, India, the South and Southwest Pacific and other hot spots. She's the only one in the world who can give you malaria, so if you can beat her, you're safe.

But don't kid yourself that it's easy. She works hard . . . and Ann knows her stuff.

This is how she does it: Ann moves around at night, any time from dusk to sunrise (a real party gal), and she's got a thirst. No whiskey, gin, beer or rum coke for Ann. . . . She drinks *blood!* And she stands on her head to get it.

She jabs that beak of hers in like a drill and sucks up the juice. When she picks on a victim who's full of malaria germs, up come the germs right into Ann's nice warm rumble seat where she gives them a free ride and they get together and make little germs . . . plenty. By and by Ann wants just another little drink and off she goes looking for a sap who hasn't got sense enough to protect himself. When she finds him, down goes her schnozzle for more blood, and all those new little germs climb down the drain pipe and into the poor guy who doesn't know it then, but he is going to feel awful in about eight to fourteen days—because he is going to have malaria.

What to do about Ann?

Never give her a break. She can make you feel like a combination of a forest fire, a January blizzard, and an old dish mop. She will leave you with about as much pep as a sack of wet sand, and now and then she can knock you flat for keeps.

The Army has anti-malaria units that carry on a steady battle by draining and filling ditches and pools where Anopheles mosquitoes breed. They also spread poison in the waters they can't drain. They screen huts and spray areas to kill them off, but in many places we have to go in this war they can't do any more than help. The real job is up to you! You will be given sleeping nets . . . use them! Night time, while you are pounding the pillow, is when Ann gets in her best licks and you get malaria. And remember this . . . All the mosquito netting in the world won't do you any good if you don't use it right away.

Keep away from the sides. And don't forget that a hole (so) big in your net can cook you. Keep 'em patched. Sew them up, or use adhesive tape. . . .

(About repellents) . . . A repellent is just a 75-cent name for stuff to put on you that will keep Ann away. The Quartermaster Corps puts out some standard repellents that are a lot hotter than the old bottle of citronella. That used to be good for about fifteen minutes a dose, and then they closed in again. These new ones will keep them off for three and four hours at a stretch. So if you must stick your neck out, douse it well with some of this dope. Ann won't like it. Put it on your clothes, too, where they are tight and thin enough for her to plug her way through. Your shoulders and the seat of your pants are favorite targets.

The Army Medical Corps has made some mosquito bombs to spray around. They kill mosquitoes and keep them out of spots like foxholes and shelter huts. The best protection you have with you all the time is your clothes. If you go running around like a strip-teaser, you haven't got a chance. Bathing and swimming at night where Ann hangs out really is asking for trouble. Head nets, rolled down sleeves, leggings and gloves may seem like sissy stuff and not so comfortable—*but,* a guy out cold from malaria is just as stiff as the one who stopped a hunk of steel.

Now if you really are looking for trouble and you don't want to miss—just drop down to the nearest native village some evening. The places are lousy with fat little Anns sitting around waiting for you with their bellies full of germs. They stock up on malaria bugs from the home-town boys and gals, and when they find a nice new sucker, they give him the works. If there wasn't enough trouble waiting for you there already, good old Ann would take care of you and make sure you got fixed up fine—for keeps. So, lay off the native villages if you want to keep the top of your head on.

What to do if Ann gets you. . . . The Medical Corps can help you recover if you get plugged, so report yourself in if you get a headache, chills and fever.

The purpose of A.G. 300.7 is self evident; it is a manual designed to educate American soldiers on the dangers of malaria and how to guard against it. But its peculiar reason for being is something else again. As Major Leaf explains: "The former technical field manuals had not done the job—and malaria is Number One enemy in the Pacific and ranks well up on the list of foes in India, Burma, China, Africa, Sicily and Italy.

By June of 1942 a vast network of joint Army-Navy malarial control units had swung into action against the fever in the Pacific. They used every device at hand—"This is Ann," quinine and the synthetics, drainage, repellents and insecticides. How effective they were can best be told in the story of Efate, one of the New Hebrides group.

When the Americans occupied the island, they found it, after the first flush of the invasion, a charming spot except for one malarious valley which in short order downed 70 per cent of the personnel with fever. The French residents shrugged philosophically and predicted that soon every American on the island would have the disease. The Americans were free of malaria when they arrived, but caught it from the natives with the mosquito transmitting the disease bite by bite. Through patient application of "malaria discipline" and mosquito-control methods, including ditching to improve drainage, and oiling of pools and puddles where the mosquitoes bred, the malarial rate in Efate was reduced over a period of a few months from

31 per cent to .02 per cent, and there is good reason to believe that malaria will never be a major problem there again.

Exact totals on the number of American personnel—soldiers, sailors, and Marines—killed and incapacitated by malaria are still a closely guarded military secret. But it has been estimated that even as recently as January, 1944, more than two years after the war began, malaria was taking two men out of the lines for every one killed, wounded or captured by the Japanese.

Authorities are more or less divided on the issue of whether or not with so many returning malaria victims in our midst, the malaria curve is not likely to keep on ascending. There is evidence for both sides. After the Spanish-American War, for instance, serious malaria epidemics broke out in such northern U. S. cities as Greenwich, Conn., Buffalo, Duluth and Cleveland; and the returning veterans at that time numbered only a few thousand.

According to Major O. R. McCoy, Medical Corps, Chief of the Tropical Disease Control Division in the Preventive Medicine Service of the Office of the Surgeon General of the Army, there is little danger of any serious epidemic of malaria on the home front traceable to returning veterans. He pointed out that there is no reason to presume that mosquito control work, on which our principal dependence has been placed for malaria control, will not continue to operate effectively despite the presence of returned soldier victims. And among soldiers, it was recently reported, the malaria situation has improved to a point where the effectiveness of combat units is no longer seriously threatened so long as "atabrine discipline" is properly maintained.

"Malaria has always been present in the United States," he said, "especially in the southeast; but, with a few exceptions, established measures have proved adequate in protecting non-endemic areas. Of course, it appears occasionally in northern states. Only last year there were 53 cases in Johnson City, Illinois, and in recent years there have been outbreaks in Iowa, Minnesota, New Jersey and Ohio, all relatively small and quickly controlled.

"Yet no attempt has ever been made here to control the movement of the human carriers to whom these outbreaks were probably due. Up until the last decade, for instance, thousands of infected immigrants from southern Europe were allowed to enter into this country and settle at will, and seasonal migration of southern agricultural workers to northern states has been encouraged. No outward consequences in the malaria situation have resulted from this policy.

"There seems to be no good reason to take a different attitude toward soldiers who may be carriers."

Another fear of the American public, that malaria, once acquired, lasts for life, is unfounded, the Medicine Division of the Office of the Surgeon General pointed out. Vivax malaria, which is the most common type, very rarely persists for more than one to two years, and three years is the maximum time, when the disease is properly treated, Lieutenant Colonel Francis R. Dieuaide, Medical Corps, Chief of the Tropical Disease Treatment Branch of the Medicine Division, said. There also is no evidence to support the fear that the disease leaves any permanent damage in its victims. Named after the species of malaria parasite which causes the benign tertian form of the disease, vivax malaria rarely causes death. Its attacks of chills and fever occur every other day.

The malignant form of the disease is known as falciparum malaria. It is this form for which atabrine, the synthetic substitute for quinine, has been found to be a cure.

Malaria is still, as it has been for some 2,500 years, "the most important disease in the world," its students believe. References to it in classical literature indicate that it was probably responsible for the deterioration of human resources that produced the collapse of the ancient Greek civilization. It was introduced into Greece when Athens was at its cultural and economic peak in the fifth century B. C. It immobilized for three years during World War One the Allied and Bulgarian armies facing each other in Macedonia; the French commander, whose force totalled nearly 120,000 men, could never get more than one-sixth of that number onto the field at any one time, and the Bulgarian commander was in a like fix. And it has given the medical men of our various services plenty to worry about. Today it is responsible for some 3,000,000 deaths among 300,000,000 victims a year. Most of it occurs in areas where American soldiers are now fighting—the Mediterranean, India, Burma, China, the Dutch East Indies and nearby islands in the Pacific.

Now every soldier in a malarious area receives "suppressive treatment"—a small dose of atabrine six days a week, which controls the disease if he should contract it while in the lines and keeps him functioning as part of his unit. If the disease should develop, or if it appears after he is withdrawn to a non-malarious rest area, he is given substantially larger curative doses, repeated each time the disease reappears.

The failure of a flower crop in far-off Kenya Colony, on the east coast of Africa, was one of the greatest boons that came to the Surgeon Generals of the United States Army, Navy and Public Health service throughout the war. It took away, at what probably was one of the worst possible moments during the war for such a thing to happen, vast quantities of pyrethum rum, a daisy-like flower of the chrysanthemum family, from which one of the few effective anti-malarials available in the early days of the conflict was made. But in so doing, it spurred the research which ultimately provided what is by far the most effective weapon against malaria carriers yet known. That chemical compound is *dichloro-diphenyl-trichloroethane,* hereinafter referred to as DDT.

The bulk of the fighting, as far as American Army, Navy and Marine Corps personnel were concerned, after the invasion of North Africa, Sicily, and Italy itself, until D-Day in France, June the sixth, 1944, was carried out in regions to which the anopheles, or malaria-carrying mosquito, was indigenous. Bataan, the Solomons, New Guinea, Burma, come immediately to mind, but some of the lesser publicized spots in which our forces were engaged turned out to be the worst pest holes of them all.

Just 32 days after the Japanese attack at Pearl Harbor, a telephone call was received by Dr. Lowell T. Coggeshall at his home at Ann Arbor, Michigan. The message was an urgent one from Dr. Ross MacFarland, who held the post of medical director of American's greatest international airway at the time—Pan American. Dr. MacFarland said that malaria was wrecking a Pan-American air base this country could ill afford to lose at such a dark moment in the war—the one major base on which we depended for air communications between America and the Middle East and India. That base was not in the Pacific, as might have been supposed. It was at Accra, on the Gold Coast of Africa, whence our planes arrived from America, via Brazil, and whence our planes departed for the Middle East and India, via North Africa and Egypt.

To Dr. Coggeshall, Pan-American's hurry-up call was welcome indeed, for the doctor had spent fifteen of the last twenty-three years on malarial study projects in our South and in Colombia, Brazil, Panama and the West Indies, as well. And at Accra he found full use for his talents. Ninety members of the Pan-American staff, out of a total personnel of 280 at Accra, were down with malaria when he arrived, and more were threatening. If the fever could not be brought under control, the base might not be able to continue in operation.

Well, the fever was brought under control, just as malaria has been in Sicily and Italy and in the far-flung islands of the South Pacific whenever our engineers and sanitation officers have had an opportunity to act. In the case of the Accra air base, for instance, large tractors engaged in runway construction were diverted to digging ditches for the drainage of shallow pools, in whose stagnant waters the anopheles mosquito found a ready breeding place. Wells were dug at some distance from the base proper and the natives induced to move their huts to them so that (1) other natural congregating places for mosquitoes would be removed some distance from the air base, and (2) the human sources of mosquito infection—for almost every Gold Coast native examined was found to be a malaria carrier—also would be farther removed from the base. The mess halls and sleeping quarters were screened, and every member of the base's personnel required to wear high boots and long sleeves and shirts which were buttoned up to the neck. Each bed was individually screened.

Priorities were granted and a Pan-American Clipper brought in 700 pounds of Paris Green, which was used to dust surfaces of stagnant ponds after a rain to kill off mosquito larvae. The Army was induced to part with some of its pyrethrum oil, with which all rooms were assiduously sprayed daily.

Ten months later, by which time the personnel of both Army and Pan-American combined had been increased from 280 to 2,660, the number of malaria cases on record for the month were just six, in sharp contrast to the 90 prevalent when Dr. Coggeshall first took over. And on December 15, 1942, when the Army Air Force officially took the place over, it was absolutely free of the disease.

It is probable that for the first eighteen months of America's involvement in World War Two, standard sanitation measures, such as quick drainage of mosquito-breeding swamps and the use of the pyrethrum sprays, had as much to do with keeping the Army and the Army Air Force and the Marine Corps on its feet as such medicines as quinine and atabrine. One group of sanitary engineers, whose officers had been trained at the Army School of Malariology, in Panama, and whose enlisted men had undergone a special course at Camp Planche, Louisiana, won high praise for the manner in which they handled the kind of problem which was forever coming up. The group was faced with a swamp separated from salt water by sand dunes. If they could flood the swamp with salt water, they could kill the young mosquitoes breeding there. But a ditch would have washed full of sand overnight and it would have taken too long to get tiles or concrete to line the ditch. The men cut the ends out of old oil drums, welded them together into pipelines and buried them in the sand. Whenever the tide came in after that, it was their pleasure to witness a perfect flushing out of the mosquito-breeding swamp with salt water.

Then there was the Australian sergeant who, as reported by correspondent David G. Wittels, practically licked malaria in one sector of New Guinea's jungle almost single-handed by means of an ingenious sign. This sergeant had experienced a familiar kind of trouble with his men. Tough troops, accustomed to facing death from bombs, bullets, shells, and bayonets daily, they thought it sissy to make so much fuss about a tiny mosquito whose bite could hardly be felt. They skipped atabrine doses, forgot to roll down sleeves and button collars at nightfall and sneaked off for showers or baths in jungle streams after dark. That's when the anopheles—the malaria-bearing mosquito—comes out of the deep grass, where it hides all day, and goes hunting.

The Australian sergeant scared the soldiers into taking the proper precautions. His solution, quickly copied by the Americans, consisted of hand-lettered signs which he plastered all over the camp. They read:

Preserve Your Manhood!
MALARIA
can cause
IMPOTENCE!

The conditions under which our mèn fought most of the first year and a half of the war, especially in the Pacific, were such that a simple stimulation toward taking even elementary precautions meant the difference between a unit going in, as one did, 6,000 strong and coming down within 30 days with 90 per cent of the line down with malaria. Tropical downpours drenched the men. The heat was intense. All day long flies pressed unmercifully against sweaty bodies in such numbers that they actually had to be pried from one's eyes and ears and nostrils. And yet at night, when the men might have found a little surcease, a little respite in the feeling of cooler air blowing against their tired and sweaty bodies, there was the constant danger of the mosquito. It was almost a sure ticket to the infirmary to bare one's chest to the breeze after the sun had set in the islands.

It is now an established fact that the casualties from malaria in our successful Solomons campaign far exceeded the number of gunshot wounds, bomb blasts and mortar bombardment. The vast majority of our malarial cases recovered, but even so the mere incidence of the disease would have cost more dearly had not the Japanese defending the Solomons suffered from it more than we did. And the Navy, in telling of its early experiences in trying to keep a controlling hand on the high incidence of malaria in the Southwest Pacific, also recounts, with especial credit, pioneer work begun on the New Hebrides island centers of Espiritu Santo and Efate, under the general supervision of the Navy's chief medical officer for the South Pacific, Captain Arthur H. Dearing, of South Portland, Maine, and led in the field by Commander J. J. Sapero, of Denver, and Lieutenant K. L. Knight, of Chicago, with Major Paul Harper, of Deerfield, Connecticut, representing the Army, cooperating.

When Commander Sapero arrived in Efate in June of 1942, the French residents predicted that every American on the island would soon come down with malaria. The Americans were free from infection when they arrived, but they caught it from the natives soon after, with the mosquito, of course, transmitting the disease, bite by bite. In one particular valley, actually 70 per cent of the American organization came down with the fever. Through patient application of malaria discipline and mosquito control methods, such as ditching to improve drainage (as had been done by Dr. Coggeshall at Accra) and oiling the pools and puddles where mosquitoes breed, the malaria rate in Efate was reduced over a period of a few months from 30 per cent to two per cent, and there is a good chance that as long as the Americans remain there, malaria will never be a major problem in that area again.

Incidentally, three types of malaria were found in the New Hebrides and Solomon Islands area. They were, Malignant tertian—or *plasmidium falciprum*—responsible for roughly 60 per cent of all malaria there, and a most serious threat, inasmuch as it causes the most deaths; Benign tertian—or *Plasmodium vivax*—not nearly so fatal, but responsible for 38 per cent of all malaria cases in the area; and Quartan—or *Plasmodium Malariae*—the toughest of all to treat, but not necessarily fatal, and responsible for only two per cent of the cases found in the New Hebrides and the adjacent Solomon Islands. It should be pointed out, however, that malignant malaria, while dangerous to life, has one advantage. Patients who do recover stand little chance of suffering relapses.

It is highly probable that, barring that crop failure in Kenya Colony, we should have gone on fighting the whole war out with these methods; in fact the man who is best qualified to know, Brigadier General James Stevens Simmons, the chief of the Preventive Medicine Service of the Office of the Army Surgeon General, has said as much. In an address which he delivered before the 52nd annual meeting of the Association of Military Surgeons, he stressed the large part played by pyrethrum sprays in the early campaigns against not only malaria, but other disease-bearing insects, and told how it was brought to its pinnacle of use by the development of a so-called freon-pyrethrum bomb, or mosquito bomb, by which means a soldier could actually keep his foxhole, shelter tent or dugout free of mosquitoes under combat conditions for as much as four hours with one single application.

Said General Simmons:

"The only insect repellent used extensively by the Army before this was a preparation containing citronella, which was relatively ineffectual and unpleasant to use. However, early in 1942, scientists at the Bureau of Etomology and Plant Quarantine, of the U. S. Department of Agriculture Testing Station at Orlando, Florida, were put to work devising an economical and effective use for distributing pyrethrum in an oil spray, and they evolved what has come to be known as the aerosol method of distributing pyrethrum insecticide by utilizing the inert gas, freon, to propel the material from a small container."

This container, which has come to be known to the entire Army as the mosquito bomb, is a black cylinder about six inches high and two and one half inches in diameter. By breaking the sealed top off it, a G.I. may uncork a misty fluid which, under vapor pressure from within the bomb, fogs up a room, kills any insect in it and retains repellent properties to discourage other insects from approaching for some time. Actually, the mixture within the bomb is made up of one per cent of pyrethrum, two per cent of oil of sesame and 97 per cent freon. The oil of sesame is a synergist, or activator, and enhances the killing power of the pyrethrum. The vapor pressure of the freon produces the necessary spraying pressure, which does not decrease as long as a drop of liquid is present in the closed container. As freon containing the insecticide is sprayed, it forms a fine mist from which the solvent evaporates almost immediately, leaving the pyrethrum and sesame suspended in the air as a cloud of fine droplets called an aerosol. The freon is non-toxic to man and mosquito and it is not inflammable. It is used simply as an expellent to disperse pyrethrum and oil of sesame.

The pressure in freon cylinders varies with temperature. For example, it is 37 pounds per square inch at 40 degrees Fahrenheit, and 84 pounds at 80 degrees Fahrenheit, and 116 pounds at 100 degrees Fahrenheit, and 205 pounds at 140 degrees Fahrenheit. Various types of freon-pyrethrum pressure cans and cylinders are available. One pound of freon-pyrethrum mixture is sufficient to spray about 150,000 cubic feet of space when properly used. It is liberated in twelve to fourteen minutes of continuous use. To spray a room, hutment or native dwelling, the can is carried rapidly toward all corners of roof, ceiling or floor, while spray is allowed to escape. No direct hits on mosquitoes should be attempted, the Army cautions, because this wastes the spray. About four seconds of spraying per 1,000 cubic feet is usually sufficient in military huts. Somewhat longer spraying for the same cubage is generally required for native huts. The Army mentions also that it is best to spray under the eaves of a hut before going inside. And incidentally, the freon-pyrethrum spray is so effective that it can be used sparingly and without wastage. When a mixture of freon and the usual pyrethrum concentrate freezes, a wax is precipitated which may block the tube of the dispenser. The wax goes back into solution after a few days at 70 degrees, Fahrenheit, or higher. So that this freezing effect is rarely troublesome in actual practice, especially since the dispenser is generally used in warm countries.

As has been pointed out, however, at just about the very moment the Army Preventive Medicine Service brought the freon-pyrethrum mosquito bomb to its highest peak of development and was getting into high gear on production of it, there came the crop failure in Africa's Kenya Colony, with its resultant shortage of pyrethrum. The United States was threatened with the complete loss of all but a very small amount of this essential insecticide material, and the Surgeon General and the special malaria control organization, which had been set up in October of 1942 when it became apparent that dealing with the malaria problem in tropical theaters of combat would be a major job, found themselves virtually back at the starting line.

General Simmons, describing the dilemma with which his organization was faced, has said: "An attempt was made to meet the pyrethrum shortage by conserving the supplies remaining in this country for the armed forces alone. Also an unsuccessful effort was made to obtain pyrethrum seeds from Kenya Colony for planting in the Western hemisphere. Nevertheless, the supply continued to dwindle. As a result, it was necessary to limit the use of the Army mosquito bomb to our overseas tropical theaters and to the fumigation of military aircraft. In other words, the situation became so serious that a substitute for pyrethrum had to be found."

Thus from sheer necessity was DDT, the greatest insecticide known to modern man, born. The antecedents of this chemical compound, which in combination with other malaria preventives was to cause the Surgeon General to report that in highly malarial theaters of war the rates are now but one third or less of what they were earlier, make the story of its ultimate development all the more amazing.

For *dichloro-diphenyl-trichloroethane,* to give DDT its formal cognomen, is not in itself a new chemical; it is, in this year of 1945, fully 71 years old. It was first synthesized as far back as in 1874 by a young student in Strasbourg, Alsace-Lorraine, by the name of Othman Ziedler, although its lethal effect on certain insect pests was not demonstrated until 1940 or 1941, when the J. R. Geigy Company, of Switzerland, and now of 89 Barclay Street, New York City, brought it out under the trade name of *"Gesarol"* as an insecticidal composition for use against agricultural pests, and also under the trade name of *"Neocid"* for use against insects affecting man and animals.

Even so, its potential value as a weapon of war as well as of peace was hardly appreciated at all. A small sample of the two compounds, which varied slightly in chemical make-up, was furnished the U. S. Army in the fall of 1942, together with information to the effect that experiments with DDT used as a spray in certain solvents in Switzerland had cleared farmers' barns of flies and kept them clear for as long as 300 days. But its chemical identity was still hidden under the Swiss trade names of "Gesarol" and "Neocid" and the Army did not have, at first, any information on its effectiveness against mosquitoes and such.

Nevertheless, because of the fly story, the Army turned the samples over, on arrival, to the Department of Agriculture, which soon broke them down. On discovering that they contained DDT, the Department promptly resynetized it and turned it over to its Bureau of Entomology and Plant Quarantine, which maintained a station at Orlando, Florida. Experiments were begun to test the accuracy of the Swiss reports of DDT as a fly-killer and also to determine its potentialities as a mosquito-slayer and an all-around insecticide.

It was soon found that DDT, by itself, had discouraging insecticidal value. However, when compounded with certain inert materials or solvents, the insecticidal properties revealed were amazing in scope. Invariably the effect of DDT compositions on insects within their scope was as follows: Nerve centers were attacked and there followed a period of violent flight or activity. Then paralysis set in, usually first in the rear legs, then completely. Death followed.

In testing the effectiveness of DDT as a residual spray against mosquitoes and houseflies, the men of the bureau in charge of this particular experiment—Arthur W. Lindquist, A. H. Madden, H. G. Wilson and Howard A. Jones —sprayed the interiors of wooden boxes, screen and glass containers and rooms with known amounts of DDT in different solvents. At intervals thereafter, as their report shows, reared four-day-old house flies were introduced and the time required to knock down 50 and 100 per cent of the flies was recorded. (The flies were recorded as down when they were on their backs and unable to crawl.)

After 115 days, the tests were discontinued until winter, when final records were made after 265 days. Tests were conducted at room temperatures which ranged from 80 to 90 degrees F. in spring and summer and averaged 80 degrees F. in winter.

9. Typhus and DDT

THE WAR AGAINST Germany and Japan had been in progress almost two full years when there was undertaken in an isolated camp in the White Mountain Forest of New Hampshire an experiment which was to have profound results. A specially selected group of conscientious objectors, 35 in all, was gathered together in this camp and set to work at repairing a washed out road. But before they donned their dungarees, one hundred carefully selected specimens of the genus *Pediculus Corporis*—the tiny gray fellow with the long nose, flat body and short legs tipped with strongly hooked claws better known to the service man and the public at large as the body louse, or "cootie"—were placed in a special flap in the seat of each man's underpants.

The louse has been called the greatest campaigner in military history. He has won more battles than any military genius who ever lived. He had as much to do with Napoleon's defeat in Russia as did the armies of the Czar, or their terrible winter. The reason the louse is so formidable is that he is the foremost carrier of typhus, the disease which has been a scourge in Europe and other parts of the Old World for ages past.

In the first World War, an estimated twenty-five million Russians had typhus. Eight million died in the Ukraine and Baltic regions alone. In 1914, Serbia was beaten early, but the Germans and Austrians delayed their advance for months. Typhus was raging in Serbia . . . typhus was holding the Serbian front! And early in the course of World War Two, the Germans had already had one bitter experience with it. That was in Poland, shortly after that hapless country was overrun by the Nazis. Civilians died by the thousands.

The Germans met the threat with the usual Teutonic thoroughness. Whole areas were rigidly quarantined. Whole zones were fumigated. But where there were indications that the disease was not to be easily headed off, the Nazis took recourse to the customary brutal—and in their lights, effective—action. Whenever some poor Pole exhibited typhus symptoms—the rash, the high fever, the little lesions all over the body, the violent and persistent headaches, the glazed eyes and the swollen tongues—he was slaughtered and quickly buried. The Nazis were taking no chances on typhus doing to the Wehrmacht what it did to the Serbian army thirty years ago.

Now there are vaccines against typhus, and powders that kill the louse, although it was something of a shock when the Office of the Surgeon General of the U. S. Army revealed quite recently that British troops who fought alongside our own in the climactic battles of North Africa were unvaccinated and suffered a so-far-unstated number of typhus casualties. Our own vaccine was developed in 1938 by Dr. Harold Cox, of the United States Public Health

Service. He applied the technique of growing viruses and Rickettsia in chicken-embryo culture.

The way it was done was to inoculate eggs that had been incubated for six days with the virus, through a small opening that was drilled in the shell. Then the opening was sealed and the egg subjected to further incubation. Subsequently the rich culture of Rickettsia which developed in the chick membrane was removed and converted into a vaccine, four shots of which were given to the American service man.

However, there were certain drawbacks. To produce sufficient vaccine to immunize a grand total of more than twelve million men and women who might suddenly be shipped off to infested lands required a fabulous number of eggs and incubating facilities, alone; the Axis Powers with their limited food resources could never have attempted it. Beyond that was the highly technical nature of the process involved and the time-consuming factor of the tedious procedure, both of which combined to make new and more quickly available sources of typhus control not only desirable, but imperative.

Somewhat different, but nonetheless compelling reasons prompted the further research as far as our lice-killing powder was concerned. We were using as a delousing agent, a gas known as methyl-bromide, which had been developed for us out of the combined research efforts of the Preventive Medicine Service of the Office of the Surgeon General, U.S.A.; the National Research Council; the Committee on Medical Research; the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture; the Food and Drug Administration; the National Institute of Health; the Gorgas Memorial Laboratory in Panama; the Rockefeller Foundation and several commercial laboratories. This, however, required the soldier to carry a collapsible fumigating bag into which the clothing was stuffed and the gas released from a small pressure vial; which was all right as long as the soldier or unit did not lose the bags or run out of them.

We also were using as a delousing agent a powder known as MYL, which, when shaken into the clothes of a service man, would keep him free from lice for about a week. But a week was the maximum, and under topsy-turvy conditions of living in the field and in the usual shambles that is a conquered or liberated city, a much longer period of freedom from lice was highly desirable.

That's how the Office of the Army Surgeon General came at this point in the war—almost two years after the Japanese attack on Pearl Harbor—to test DDT for use as an anti-typhus weapon. That's the reason they were putting "ants" in the underpants of the quiet group of college professors, farmers, clerks, salesmen, artists and professional men—conscientious objectors all—who had voluntarily journeyed to that camp in the remote section of the White Mountains for that express experience.

Basic requirements of the test were that each volunteer be physically fit and able to do work that would compare with the physical activity of a soldier at the front. And so the thirty-five conscientious objectors involved in this experiment were not locked up in an isolated cabin, as were the soldiers of an earlier war who helped Dr. Walter Reed discover a control for yellow fever; rather they were kept at work repairing the washed-out forest road, while the lice in their underclothing went to work, too, laying eggs.

The men were, however, under a most trying and exacting admonition. With literally thousands of cooties romping through their underclothing, they were not permitted to scratch. And, as a matter of record, the figure "thousands" is not used loosely. For after the first day, it also became an integral part of the experiment for the men to be stopped at least once every twenty-four hours and subjected to a count of their unwonted body-guests. and, as you may well imagine, the figures set down in that daily count soon reached proportions astronomical.

Then, at intervals of two weeks, it became the practice to administer to control groups anti-louse powder compounded out of such bases as talc or pryphylite and varying percentages of the whitish, sticky, odorless and almost tasteless mixture of chemicals known as DDT. Its propensity for sending insects, including lice, into first a sort of nervous agitation, then into a positive "drunk," then into a state of paralysis and finally into a coma which ended in death already was known. But the questions that were troubling the Office of the Surgeon General were: Could DDT be used on millions of service men and civilians with safety? Could it be safely applied to the human skin?

Other tests had shown that when eaten in relatively large amounts by rabbits, guinea pigs and other laboratory animals, DDT in certain arbitrary compounds had caused nervousness, convulsions and ultimately death. It also had caused necrosis of the liver and kidneys in these animals. University of California entomologists had observed that a flock of sheep, allowed to graze in a field that had been dusted with DDT powder, had developed a spastic twitch in their hind legs and kept their heads to the ground as if paralyzed and were unable to eat for several days. Only goats appeared to be totally immune to some after-effects of either ingesting, inhaling or absorbing certain compounds of DDT either orally or through the pores of the skin. And, to put it another way, how much might a human being breathe in or otherwise absorb without similar ill effects?

In due time, it was learned that DDT could safely be applied to the human skin in a formula, the proportions of which the War and Navy Departments prefer for reasons of security to keep secret at this time. And that, unless breathed in fairly constantly, DDT in the proportions used in this formula is not toxic to human beings. That, in fact, a man might breathe in as much as is contained in a two-ounce can of the powder, composed, of course, of the proportions of DDT and talc and pryphylite worked out by the Office of the Surgeon General in these and other experiments. Here again, the figure of speech "due time" is rather relative; for in the early days of those experiments in the White Mountains, it was found that certain compounds containing DDT set up skin irritations among the human guinea pigs who had volunteered for these trying tests that were dangerous to health. And the fact is that the thirty-five conscientious objectors who signed the customary waivers saying that they would not hold the Government of the United States legally responsible for anything adverse that might happen to them in the DDT test, signed up over and over again—or in other words, for a total of three three-week periods—before the bugs were worked out of the DDT formula. . . .

As is the customary government practice, the thirty-five conscientious objectors who submitted to having one hundred lice apiece placed in their underclothing and placed there to multiply were never told the results of their work. But it was only a few months after the White Mountain Forest experiment that the Army of the United States went through Naples, Italy, spraying everything and everyone with torrents of DDT, thereby averting a disaster to General Mark Clark's Fifth American Army similar to that which befell the Serbians in 1914 and the Russians in 1916 and the Poles in 1942, and bringing under control an epidemic of typhus which already had gained a considerable hold.

In December of 1942, President Roosevelt, at the request of the Surgeons General of the Army, Navy and Public Health Service, created by executive order the United States Typhus Commission. This was a commission comprised of Army, Navy and Public Health officers functioning directly under the Secretary of War, whose responsibility it was to control typhus in whatever lands and areas were under the direct control of the United States Army or Navy and in whatever lands or countries its good offices would be accepted by the governing authorities. In the course of its operations, not the least of which was preventing American doughboys fighting in North Africa and Sicily from contracting typhus from close association with their unvaccinated brothers-in-arms—the British—a field office had been set up in Cairo, Egypt, under the directorship of Brigadier General Leon A. Fox.

Typhus had been rumored in Naples as far back at March, 1943, which was a full six months before the Fifth Army entered the city. But in December of that year, word reached the commission's Cairo offices that the number of cases being reported alone had attained the high average of 35 a week. We do not know how many cases went unreported in that wholly disorganized community. Shortly after this there came a direct appeal to the commission from local authorities for diagnostic aid.

As they have said in reports to the commission, of which both were members, Commander Andrew Yeomans, U.S.N., and Major John Snyder, formerly of the Rockefeller Foundation, flying to Naples in response to the appeal, found not only a need for diagnostic aid, but a crying need for strong control measures, and at once. The disease not only had taken a firm hold, but it was spreading rapidly. As against a total of thirty-six cases reported for the week ending December fourth, the week ending December seventeenth had shown thirty-three, the week ending December twenty-fourth had shown fifty and the total in the week ending December thirty-first had jumped to two hundred and eight. A trained field force of diagnosticians, physicians, laboratory technicians, sanitary officers was needed at once if the American Fifth Army was not to be exposed to one of the most dangerous of epidemics; and with it plane loads of vaccine, MYL anti-louse powder, methyl-bromide gas fumigating equipment and DDT.

Such a force was gathered together, and a vast supply of vaccine and DDT was flown in, with General Fox himself accompanying it. His first move was to arrange with Fifth Army Headquarters to have Naples put "out of bounds" for all soldiers except those essential to military operations, thereby enhancing by a great deal the chances of localizing the typhus outbreak and confining it to Naples. After that came moves to augment his basic force with a staff of local Neapolitan doctors and nurses, and to divide the anti-typhus campaign into five departments, with one division assigned to search the city for those already down with the disease and to bring them to isolation hospitals; a second assigned to immunize by vaccine and DDT those persons who had been in close contact with the stricken; a third given the task of inducing public officials, priests, teachers and local doctors and nurses to submit to quick and semipublic vaccinations in order to overcome by example any fears that might be held by the great mass of the people; a fourth assigned to the tough job of rounding up refugees who were being pushed by the Germans through the American front line; and a fifth assigned to the monumental task of delousing the Neapolitan population at large. After that, General Fox undertook to fumigate and delouse the great system of subterranean caverns, some of them more than a mile long and maybe forty or fifty feet high, in which something like twenty thousand Neapolitans had taken to sleeping almost nightly since the invasion of Sicily had first brought about intensive bombing raids on the city.

The reactions of the local population to General Fox's immunization program were many and various. The group of public officials, teachers, priests and even physicians, on whom the general had more or less relied to pave the path and break down resistance of the public at large against vaccination, included many who absolutely refused to take the vaccine. Apparently anti-vaccination propaganda is even more widely disseminated in Italy than it is still in certain sections of the United States. On the other hand, the lowly Neapolitan took to the whole idea of free immunization against typhus with such gusto that General Fox's squads found themselves delousing at least a quarter of the population twice. Especially was this true of the treatment with DDT. Some forty-odd delousing stations had been set up in various buildings throughout the city, and to them, in response to radio appeals, pronunciamentos in Naples' one daily newspaper, signs and placards on the walls, yes, and exhortations from the pulpit and from the podium, came the young and old, the lame and halt, the rich and poor to have the sticky, white, odorless and tasteless powder known as DDT sprayed onto and into and under their clothing. The overall reaction of the Neapolitans to the prospect of immunity to typhus held out by the magic powder to which the thirty-five forgotten conscientious objectors submitted experimentally in the earlier months of that same year was best described by War Correspondent Allen Raymond in an article entitled "Now We Can Lick Typhus," which was published in the April 22 issue of the Saturday Evening Post. Said Mr. Raymond:

"It was not only the poor who went to these stations to be treated with all their clothes. The well-to-do went also. Soap had been obtainable only at highest prices, and occasionally not for months, and people far above the income levels customarily associated with squalor flocked to get this service. I met one American woman, the wife of an Italian engineer, who for many months had been able to get only enough soap to care for her two small children. For her own toilet she had used pumice stone, which is plentiful in this neighborhood, softened with olive oil. Cleanliness had been a matter of real difficulty for a long time.

"Probably, however, ten per cent of the poorest people of Naples had ninety per cent of the city's lice. There is always a definite relationship between typhus immunity and prosperity in the populations of every stricken area."

Then Correspondent Raymond went on to point out that the worst breeding places for typhus in the area were the 600-odd caves under the city. The United States Typhus Commission's drive to fumigate those caves was probably the high point and the turning point in the battle to hold down the Naples epidemic and prevent it from bringing disaster both on the people of Italy as a whole and on the American Fifth Army and its British, French, Canadian, and Polish allies campaigning there. For as has been pointed out, some 20,000-odd homeless, dirty and distraught people, without even elementary necessities for maintaining bodily cleanliness, had been squatting and sleeping in their dank and sunless passages for three-quarters of a year and the extent of their infestation with typhus-bearing lice was almost beyond comprehension. Furthermore, there were more than six hundred of those caves in number; actually it took the physicians and sanitation squads of the Typhus Commission sixty-one days to cover them all and to spray them with DDT.

What was the result of all this?

Well, as has also been pointed out, the number of typhus cases reported in Naples during the period from December fourth through December thirty-first of 1943 was 312. That was followed by two peak weeks—the weeks ending on January seventh and January fourteenth, 1944, when the totals were recorded as 311 and 231, respectively. Then began a decline. Not a fast decline; the weeks of January twenty-first and twenty-eighth tallied 158 and 163 new cases of typhus reported, and the week ending February fourth still listed 99. But from then on it was easy sailing; 49 new cases reported in the week ending February eleventh, and 39 in the week ending February eighteenth.

A total of 1,377 cases of typhus reported in the city of Naples in little over twelve weeks. But also the eradication of typus from Naples in that same time, and most of it due to the magic of DDT.

Not a single American service man died of typhus during the twelve weeks the United States Typhus Commission was busy spraying Naples with DDT. One soldier did come down with the disease, but his attack was so slight that it required laboratory tests to diagnose it and he was up and about in less than a week. And by an odd circumstance, one American sailor contracted the disease, too. It seems that he was allowed to straggle ashore in the pest-ridden port without ever having been subjected to immunization treatments at all. But those were the only instances of the disease among our troops during the whole raging epidemic. And when contrasted to the incidence rate of the disease in the Russian and Serbian forces of World War One and the devastation typhus wrought at that time—eight million Russians, service people and civilians combined, dead of typhus in the Ukraine and Baltic regions alone, and one million Serbians and their neighbors dead of typhus in the Balkans—the picture is almost breath-taking.

In the words of Brigadier General James Stevens Simmons, present chief of the Office of Preventive Medicine under the Surgeon General of the United States Army, and who for more than thirty years has devoted his life to the science of public health: "Thanks to DDT, typhus—ruthless companion of disaster, famine and poverty—has for the first time in history lost all right to its murderous title of champion of the ancient plagues of war."

Of course, as Brigadier General Simmons also has been at some pains to point out, our primary interest during these years of war has been in the value of DDT as a new weapon for use in the field of military preventive medicine. But if as has been proven by tests again and again, as little as two pounds of DDT dissolved in one hundred gallons of water can make a spray capable, *with only one application on the walls and ceiling,* of keeping an ordinary barn holding twenty-four cows absolutely free of flies for two whole months—if one pound of DDT in a five per cent solution of Diesel or fuel oil can make so effective a larvicide that, dropped on the surface of a pond, it can kill all the mosquito wrigglers in five acres of water—if the ordinary two-ounce can of the powder carried by the soldier can, as has been repeatedly demonstrated, not only keep the soldier's clothing free of mosquitoes and lice for eight weeks at a time, but also immunize him from bedbugs and to some extent also from ticks and chiggers—then the postwar potentialities of DDT are almost infinite. It means carpets, blankets and other heavy woolens will be mothproof in spite of repeated cleanings or washings; wall paint will keep even open porches as well as household rooms and milk sheds and chicken pens and dairy barns clear of flies and other insect pests for a whole summer at a time. DDT-treated bags will protect foodstuffs against flies and kitchen ants; beach and lake resorts will be free of mosquitoes; gardens may be rid of Japanese beetles; and orchards, perhaps, of the coddling moth. Even cats and dogs should be flea-less. But how soon is a matter for debate.

Even Brigadier General Simmons, who felt that the dusting powders and sprays worked out in advance of the Naples epidemic were safe enough to permit application to more than one million and three hundred thousand persons, says: "Such a powerful insecticide may be a double-edged sword. Its unintelligent use may eliminate certain valuable insects essential to agriculture and horiticulture. Even more important, it might conceivably disturb vital balances in the animal and plant kingdoms and thus upset various fundamental biological cycles." And there is an affirmative echo in the words of Dr. Amos E. Badertcher, chief entomologist of the McCormick & Co. plant in Baltimore, Maryland, which has manufactured and is manufacting vast quantities of DDT dusting powders and DDT sprays for the Army. Says Dr. Badertcher: "DDT has a definite repellent value. I have sprayed the screens on one side of my home, normally thick with flies, and found that afterwards even an almost invisible deposit of the compound has resulted in a complete absence of flies for long periods of time. Whereas the screens on the other side of the house which I did not spray continued to draw or become the landing field for their usual and normal complement of flies and other insect pests. I also have talked with service men who witnessed a pre-invasion spraying of one mosquito-ridden island of the South Pacific by low-flying bombers, and was told that even after that single spraying the only insect left alive was one lone butterfly.

"However, on the basis of that very testimony it is my belief that DDT should be and will be put in the hands of trained users after the war. DDT kills a greater variety of insects than any other insecticide because of the long-lasting toxicity of its residual deposits to succeeding generations of insects. And therein lies its greatest danger.

"Mankind has many friends in the insect world and DDT is equally destructive to friend and foe. Should nature's balance in the insect world be upset, the effect on man would be deplorable indeed. Also the extent of DDT's toxicity to man and to domestic animals is still uncertain. The potentialities for serious damage through its misuse by the inexperienced operator are too great for chances to be taken with it."

Regarding this problem, and especially as it concerns the farmers of the nation to whom DDT can ultimately turn out to be a true friend or a dreadful foe, the University of California has made certain reports on field tests made by its entomologists which may serve as a guide. They found, for example, that DDT proved the first satisfactory chemical control for lygus bugs, the insect pest which attacks alfalfa. It also stopped the potato leafhopper, the coddling moth—whose larvae bore through the shells of California's money crop of English walnuts—and the onion thrip. It was a promising prospect for a vineyard pest known as a grape leafhopper.

However, the entomologists of the University of California also were forced to report that walnut trees, when sprayed with DDT solution, not only lost the coddling moths, but the ladybird beetles which are nature's own control over another pest called the walnut aphid—a tiny yellow insect that hides on the under side of leaves to extract the sap. The aphids, too, were killed; but more showed up in due time, although no more ladybird beetles did. As a result, walnut trees began losing their leaves and only an emergency dusting of nicotine was able to save them.

A similar experience was noted in a test-spraying conducted in an almond grove. Both the brown mites and the two-spotted mites, which, like the walnut aphids, attack the leaves, were wiped out by a solution of DDT. Their natural controls were also killed. But the mites soon reappeared and ultimately stripped the trees of all foliage because their natural controls did not, for some inexplicable reason, reappear too.

Experimentation also proved that DDT is definitely toxic to bees, the chief spreader of the pollen from many blossoms. Moreover, it also has shown that in some cases, plants being treated with DDT for insect control were themselves damaged by the insecticide. Tomatoes are a case in hand. Greenhouse plants, sprayed four times with DDT, suffered little loss from spotted wilt, a virus spread by thrips which were killed by the DDT solution. But the same plants were severely burned by the spray itself, and all the lower leaves of DDT-treated plants dried up and died.

Those conducting the University of California research feel that in the last analysis the solution to the plant damage problem will be found in correctly establishing the best concentrations and spray medium for DDT's many uses. For instance, when combined with an oil, it penetrates more deeply, because the oil carries into skin or plant tissues. The implications of this become at once apparent when one reads on in the University of California report to find that oranges sprayed with DDT in oil were found to give evidence of the insecticide clear through the peel.

DDT, it would appear, works effectively at much lower concentrations than other insecticides. One pound of it to one hundred gallons of water was used in a spray to cover the same number of trees that required four pounds of lead arsenate for spraying. In an experiment with a three-acre plot of alfalfa which yielded an average of 14.6 lygus bugs per sweep of an insect net, twenty pounds per acre of three per cent DDT in pyrophylite dust was applied. Only two days later it was found that ninety per cent of the bugs were gone. Incidentally, two weeks later it was found that the lygus population in the control plot had increased to 10.46 bugs as compared with 48.7 found in an undusted field nearby. Bugs in the DDT-treated area were mostly adults, indicating that they had flown in from untreated areas.

This particular three-acre test plot of alfalfa was then dusted again. It reduced the bugs to 4.47 per net sweep. But here the University of California entomologists ran into a problem: the dusted area freed from the lygus pest had a more healthy bloom and stood out from the rest of the field as a purplish patch, with the result that lygus bugs from areas they themselves had blighted flocked in droves to the DDT-dusted field.

The University of California researchers also looked into the problem of how much DDT can be left on fruits and vegetables to be eaten. On this phase, Dr. Herbert O. Calvery, of the U. S. Food and Drug Administration, has declared: "The safe level in human food cannot be over ten parts per million, if animal test data are right." And the California researchers added to this statement their experience with sheep. A flock which was allowed to graze in a field which had been dusted with DDT developed a spastic twitch in their hind legs, not to mention a habit of rubbing up against fence posts and keeping their heads to the ground as if paralyzed and being unable to eat for several days.

Dr. Badertscher, of the McCormick plant which manufactures so much DDT for the Army, had some testimony to add to this. He reports that the immediate effect of DDT on insect and laboratory animals was to induce a nerve condition with paralysis, which is followed, in the case of insects, by death. Long exposure causes necrosis of the liver and kidneys in laboratory animals, although this damage has been successfully repaired by treatment. Dr. Badertscher also is of the opinion that the chemical is poisonous if inhaled, ingested or absorbed in large quantities. However, he has qualified this by saying that he does not believe the dust or powder in diluted form is toxic—that is, unless breathed in fairly constantly. And he says that certainly a soldier may breathe as much as is contained in the little two-ounce can he carries labeled "Insecticide Powder for Body Crawling Insects" without ill effects.

Dr. Badertscher points out that in dry form, DDT causes no apparent contact damage in humans. Only the oil sprays offer any danger of absorption. The emulsion does not penetrate the skin and leaves only a residue which washes off easily. It is generally believed that animals which do not lick themselves very much are safe from any use of the spray or dust that does not lie in an oil base. However, not enough is really known yet of DDT's action on animals to say whether or not your dog or cat could be safely dusted or sprayed. Only goats apparently are sure bets for immunity at this stage of experimentation.

Incidentally, McCormick & Co. take no chances on the toxicity of DDT as far as their employees are concerned. Perhaps the safeguards used by this company suggest the proper precautions to be observed in the handling of this chemical until research tells us more concerning its properties for harm to humans. The company shuts off its plant from its offices with dust-proof doors. Those working on the dust must wear respirators and those working on the spray must wear rubber gloves. All have clean uniforms every day and wear caps as well. They are required to bathe before leaving the plant each night and must scrub their hands with a brush before eating. Regular X-rays are taken and full medical examinations made at stated intervals to check on their health.

Entomologists do say that it may be possible to get around the problem of DDT's menace to human beings, plants and animals, at least insofar as it concerns the farm and the orchard. They point to DDT's long-lasting power against insects, and they say that it may be possible to spray plants before any sign of fruit or vegetable appears, and yet kill off the insect pests that attack a month or so later. They say that by applying DDT before fruit flowers appear on plants and trees, it may be possible to avoid the danger of killing off the bees—the natural pollenizers. This, because the bee travels by air direct from flower to flower and is not so apt as other insects to settle on a sprayed leaf or stem.

Civilian research has been handicapped, of course, by the sparse amount of the magic powder made available for that purpose. To the University of California, for instance, only 250 pounds were allotted for all the experimentation it undertook in 1944; the full production of almost two million pounds a month being taken direct for military needs. However, there is now hope for a larger allotment to laboratories and universities anxious to undertake the further necessary tests.

All authorities are hopeful for the future. Dr. Badertscher thinks that DDT's long period of toxicity and the fact that the substance can be synthesized commercially at a relatively low price will mean much in the post-war world. The two-ounce can of dusting powder such as the G.I. now carries probably will be available for as little as twenty-five cents. There will be a commercial saving, too, in the fact that the one insecticide will control several types of pests and thus cut down on the number of applications. It is pointed out that two quarts of the liquid will cover an acre when sprayed from a plane.

Post-war use may also involve the aerosol bomb, by which only four ounces of DDT can treat 240,000 cubic feet of space. This bomb has been used with great success in experimenting on range cattle. With DDT the cattle require only four sprayings a year, although their immunity from toxicity of DDT is still subject to question.

Perhaps Brigadier General Simmons has summed up best what is in the minds of all researchers who have had experience with the magic white powder. He says:

"The possibilities of DDT are sufficient to stir the most sluggish imagination. And even if all investigations should cease today, we already have a proud record of achievement. In my opinion, DDT is the war's greatest contribution to the future health of the world."

10. Inventors and the War

THE WORLD WAR is crucially dependent upon things just as small as the nail which lost Richard III of England his kingdom according to the old jingle which traces his defeat on the battlefield to the lack of a horseshoe nail. Being a total war, it includes thousands of equally obscure items, the lack or failure of just one of which could drastically imperil not only the lives of our fighting men but throw the whole nation's efforts toward victory seriously out of kilter. Nuts and bolts, electronic tubes no bigger than your little finger and flashlight batteries hold together the American war machine.

Take dry cell batteries. Try to figure out just how much good mine detectors, "walkie-talkies" and "handie-talkies" would do our armed forces if there were no small dry cell battery to make them work. Or do what the Army did. Ship thousands of these three items, complete with batteries, into the South Pacific where a lot of determined Americans were trying to push twice as many fanatical Japanese off a thousand and one steaming islands, only to find that the equipment didn't work. The high temperatures and humidity were ruining the batteries. Nine tenths of them were shot in transit; the remaining tenth petered out after a few days' use in places where the thermometer often hits 120 degrees.

Fortunately, in the case of the mine detectors, the situation wasn't acute. The Japanese aren't given to sowing mines in the profusion customary with the Germans. But the failure of the "talkie" equipment was tough; for in this war the "walkie-talkie" and the "handie-talkie" have taken the place, almost exclusively, of the courier. These portable sending and receiving radio sets, light enough to be carried strapped on the chest and shoulders of a man, make direct and speedy communication possible between advanced units in a field and field command posts.

The "walkie-talkie" is the infantry's instrument. Its only bad feature is that its antenna, which projects from the boxlike apparatus on the back, extends a good distance above the head and in certain terrains make the operator an enemy target. Because of this, the infantry in the hedgerows of Normandy used handie-talkies. But this smaller version of the walkie-talkie was primarily developed for the paratroops. It is considerably lighter, and its antenna dangles from the wrist with a weight at the other end just heavy enough to give it tautness.

Perhaps in no other theater of the war was the failure of equipment so drastic as was the lack of efficient "talkies" in the Pacific. Both the terrain and the type of warfare being waged—the matted jungles and torturous mountains, the infiltration tactics of both sides, made it all but impossible to keep up communication by means of couriers.

As a result the Signal Corps found itself deluged with requests for huge shipments of fresh batteries for the Pacific area. And when the orders were filled fresh howls went up from shipping officials over the amount of space being consumed in the crisis. There didn't seem to be much to be done: the Signal Corps tried various ways of packing the batteries in order to prolong their life at least through shipping, but the traditional dry cell battery has a porous surface and has to be allowed to "breathe," and nothing efficacious could be worked out. More or less as a matter of wishful thinking, the Corps began looking around for an alternative: a battery that would do the job and still stand up under tropical temperatures.

What the Signal Corps was looking for was still only a gleam in the eye of Samuel Ruben, an inventor of no small repute who, in his private New Rochelle, N. Y., laboratory, has turned out several hundred electro-chemical, electronic and electrical improvements for modern living, one of which—a condenser—made possible small, table-model radios. Mr. Ruben stopped in one day at the small suite of offices in the Department of Commerce building in Washington occupied by the National Inventors' Council. He had two inventions he wanted to discuss with the Council, but his visit was primarily a patriotic one: he wanted to know what was needed by the armed forces, so that he could try to work something out for them. The Council was only too glad to oblige. It had a long list of needed Army and Navy instruments, weapons and improvements, ranging from detectors of non-metallic mines to a self-inflating life preserver which would automatically turn a man over on his back. Among them was the Signal Corps' request for a heat-resistant battery. Ruben returned to his laboratory and in a short time the Signal Corps was shipping out to the Pacific theater a mercury dry cell battery, five times as durable as a standard unit, a battery so small that more than a thousand of them could be shipped in the space formerly occupied by five hundred of the old type. And, where the flashlight-type batteries would last on an average of only twelve days in the tropics, the new miracle batteries were still going strong on their sixtieth day.

The new Ruben battery which, incidentally, puts its inventor among the ten civilians holding a Certificate of Appreciation—a sort of an individual Army-Navy E award—is so good that the Army recently cautioned officers in the field against over-ordering.

The peacetime possibilities of the mercury battery are enormous, even though it is more expensive to manufacture than the traditional type. But in such things as hearing aids, fire alarms, portable radio sets and intra-train communications, where the small size and long service of the tiny battery outweigh its cost, the unit will find ready markets. Don't expect, however, to hear, in all the fanfare of publicity and advertising that will herald the tropical long-life battery on the post-war market, any mention of the part played by the National Inventors' Council in expediting its passage to the South Seas. There won't be any. The Council is the forgotten bureau of Washington. War agencies forget to say thank you, or even to give credit where credit is due in at least seventy-six instances where the Council placed the right invention in its proper military niche.

That is the Council's function in life—being a central, governmental clearing house for war inventions. It was formed in 1940 for just such emergencies as the Signal Corps ran into with the batteries. It started out as a triple play: from Lawrence Langner, now acting as secretary of the Council, to Harry Hopkins, then Secretary of Commerce, to the late President. It began life by operating on monies from the President's Special Fund.

Actually, it is the altruistic brain-child of Lawrence Langner, who is popularly known for his avocation—the theater—rather than his vocation. In the world of science he is known as a partner in a prominent firm of international patent lawyers, and that explains the National Inventors' Council.

The job of organizing the agency was passed along to Dr. C. F. Kettering, Vice-President of General Motors Corporation and Chairman of the Council, himself an inventor. He fathered the automobile self-starter which made it pleasant and practical to own a car. Dr. Kettering gathered together a group of leading American scientists and industrialists to work at the job of tapping the nation's inventive ingenuity in solving military and naval problems.

In the last war, Thomas Edison did much the same thing by setting up the Navy Consulting Board. But this agency was much more restricted; it concerned itself mainly with methods for coping with the submarine menace. Even at that time it received a grand total of 125,000 suggestions; only one was adopted, and this bore no relation whatever to submarines.

The National Inventors' Council, on the other hand, opening wide its doors to America's ideas, inventions and just plain suggestions on any and all subjects relative to the war effort, has to date received 332,578 written and oral proposals. These ideas have come into the Council at the rate of 125 a day; though for a period after Pearl Harbor, the agency was snowed under by an avalanche of 2,500 daily suggestions. Of the grand total of ideas submitted, one hundred and ten are now in the process of being investigated by war agencies, while 76 have been accepted and are in use by several branches of the armed forces.

One of the most important rescue aids in survival equipment, a small, specially devised signaling mirror, is the baby of the entire National Inventors' Council. The agency was asked by the Office of Strategic Services to hurry along some sort of a reflective device with which men down at sea, or lost in jungles or deserts, could signal passing ships or planes. Reports going into Strategic Services showed that dozens of survivors, who might otherwise have perished, were being spotted and rescued because a piece of broken pocket mirror or a bit of polished tin had been used to dance a sunbeam into the eye of the pilot of a passing plane. A reflector which would withstand salt water, packing, and being kicked around in the bottom of lifeboats and rafts was needed to go into life-saving kits. So the engineers of the Council, under the direction of Commander F. A. Hunnewell, started a search for a mirror with a maximum reflecting surface, strong enough to stand the ravages of jungle, sea and desert, compact enough to fit into a tightly packed kit and able to be aimed or sighted at passing rescuers. Because the agency has no laboratories, the Bureau of Standards ran tests for them on materials. And what they came up with was the Hunnewell Signalling Mirror, a small three- by five-inch rectangle of heavy, mirrored plate glass with a cross-shaped aperture of clear glass in the center for sighting. More than a million of them have gone into Army life-saving kits and their operation is simple. All that is necessary is that it be first sighted along the surface, then raised slowly to the object to be hailed and flashed at one second intervals. Nine times out of ten in clear weather, the flashes can be seen for a distance of ten miles, a remarkable improvement indeed.

The Navy, however, was willing to sacrifice some compactness in order to get a device that would flash in color, preferably orange or red. Navy fliers and sailors, as a rule, go down in the sea, and it was discovered that the flash from a colorless mirror was often mistaken for sun glints on the crests of waves. So the Navy asked the council for a signalling mirror in technicolor. Since a classified record of every suggestion, idea and invention submitted to the Council is maintained, the agency went back over its files for a vest-pocket heliograph suitable for Navy needs. A device submitted some time earlier by a California gas station operator was dug out. The heliograph, which had been developed by its inventor some years before the war for his Boy Scout troop, had been passed along by the Council to both the Army and Navy. Both had rejected it on the ground that it had to have its own container, which made it unhandy. But the Learned Signalling Device has small squares of orange glass imbedded in its metal frame and a center sighting flap through which a disk of red light can be focused. It can also be used at night by flashlight. So the Navy reconsidered and finally adopted it as the standard signaller for aircrew survival equipment. Its inventor presented the device freely to the government, refusing at first to patent it. But the council, following its policy of avoiding embarrassing entanglements for all concerned, advised him to register the device. A war-converted toy manufacturer is now producing the Learned Signalling Device.

One day a man came to the Council with a home-made invention for locating U-boats. It was an odd-looking contraption about the size of a small steamer trunk connected to an earphone headpiece by a couple of straggling wires.

"I'm a Florida treasure hunter," he told the agency's interviewer. "I invented this apparatus myself and with it I've been able to locate in the sand brass cannon from sunken Spanish galleons, and I've even found a treasure ship lost in the days of the Spanish Conquest by using it."

The Navy didn't want it. There were other devices and techniques at hand or under way which were serving the purpose. So the Council started sending it around to the various departments of the Army and it kept getting turned down until it hit one Army department that realized its significance.

The Signal Corps snapped up the treasure hunter's U-boat finder. Plans were well under way for America's first invasion of Hitler's conquered world, and time was running short when we were to take that first step toward victory, North Africa. Rommel had literally sown the deserts of Africa with tens of thousands of magnetic mines and American forces had no means of detecting them. The British had a land mine detector of sorts, and the Germans had one, though they'd had little need to use it. The United States, however, was faced with the prospect of landing thousands of invasion troops in a quagmire of death, where the very act of putting foot to ground was enough to blow a man to smithereens.

The treasure-hunting contraption was simplified, streamlined and improved. The unhandy, trunk-size apparatus was converted into the mine-finder that we know today, the sapper's weapon that looks for all the world like a housewife's new-fangled vacuum cleaner. Then it went into production. There was no time to lose and when a bottleneck in production appeared because of a delay of a vital part, the parts were flown to the manufacturer by plane. For weeks before the invasion date, girls on the assembly line worked thirteen hours a day. And on the date specified, the mine detectors were ready—more than had been ordered.

The path was a narrow one in Africa; it was even narrower in Sicily and Italy. We dug up the anti-personnel mines spotted by the detectors and left markers pointing the way to safety. Then the enemy grew increasingly cunning and planted the fields and roads of Sicily and Italy with anti-tank mines . . . mines which waited for the heavy rumble of an American tank before they belched forth death.

The commanding officer of a tank corps watched day after day through the Sicilian and Italian campaigns as the smashed and burned bodies of his men were pulled out of the twisted steel coffins of their tanks. Finally, he could stand it no longer. He sat down and with wavering lines drew, on a piece of smoothed out paper, the design of a double roller device to be attached to the front of a tank. He had it pretty thoroughly worked out: the double rollers would be heavy enough to act as detonators, and by using two or three tanks so equipped, more room could be cleared in far less time than it took to work painstakingly with the portable detectors. The wavering sketch and a hurriedly written description of the design, signed simply with his name and APO number, came in one day to the National Inventors' Council in a batch of overseas mail.

The invention was turned down. A stilted letter of rejection was mailed to his APO number and a Council bulletin enclosed. This, for some unfathomable reason, was removed by the Army censors. The letter received in return by the agency is a sarcastic example of the scorn felt by a fighting man for the man behind the desk.

"I am honored indeed by the accolade of the Council and the generous recognition accorded by the technical staff. It would be interesting to read your reports on this subject, though the realization of the carnage among the shattered mahogany desks and twisted filing cabinets might well shrivel the nerves of a carboloy cobra.

"We in Italy can do little in comparison with the magnificent magic of the iridium intellects. We have to grub about with odd bits of primacord detectors and patty-cake in the mud.

"We do our best in our poor way and it may be our proud privilege some day to stand in the admiring throng that watches the parade up Pennsylvania Avenue and remark to the envious unbelief of fellow bystanders: 'They wrote me a letter once. They forget to enclose the circular, but then a feller can't have everything.' "

This time he signed his rank. It was possible then to tell him the story. An anti-tank mine detonator was already in production, would soon be on the way to Italy. Another man had also worried about the high percentage of deaths among tank crews due to German mines. He was Fred Zeder, vice-chairman of the board of directors of the Chrysler Corporation. He had gone to Chrysler's staff of engineers and laid the problem in their laps. It was comparatively simple for them to solve. Chrysler was already building American tanks, and a detonating device to be used in conjunction with them was quickly worked out. Then Zeder had a full-scale, thirty-thousand-dollar working model made for the Army, who snapped it up. The Chrysler mine-detonator was similar in some respects to the soldier's. It also used a roller attachment, but a single roller made up of a series of independently hung, cogged wheels. Each wheel was capable of exploding and taking by itself the force of an exploded mine, thus saving lives.

That was in the fall of 1943. By D-Day in June of 1944, American invading forces were able to land on Normandy beaches swept clean of anti-tank and anti-personnel mines.

An invention which had to be actively peddled by the Council was a plane trolley. This device, an ingenious arrangement of guy wires and cable, was developed by its inventor to take planes off from ship deck. The Navy wasn't interested in it. Navy planes are too heavy to use the device. So the invention was sent through Army channels. It snagged at last on a reconnaisance unit, using Piper Cubs and other small planes for front line photography and observation. The little two-seaters, flying at low altitude and unarmed, very often are forced down, or have to seek cover from fighters in the first available spot. Such landing fields are often one-way propositions: a plane can land, but can't take off; and if it happens to be behind enemy lines, the two-man crew is in an extremely ticklish spot. So the plane trolley was taken up by the Army. As a matter of fact, it is serving a two-fold purpose: for forward positions in rough terrain where no cleared place exists for the observation planes to take off, the trolley is used to get them off the ground; and for downed planes in the same predicament, a rescue unit can drop the device to be rigged up by the two-man crew.

Like the peacetime profusion of promoters of perpetual motion machines, war brings forth a crop of inventors of invisibility for fighters. The following letter, lending a somewhat novel angle to this old theme, reveals a spirit as frustrated as that of the tank corps officer.

"Dear Sir:" it addressed the President, who had turned it over to the Council. "I am a boy of 13 and I will give my 2 real reasons for writing this letter later.

"I have an invention that may prove valuable to the United States Armed Forces, (please read the rest of the letter). My question is if I give this invention to the United States Government may I join the U. S. Marine Corps. My invention is invisible suits for the Armed Forces of the U. S. by using invisible ink on paper or the painted suits which the armed forces use for camoflage as you already know. But if you accept my invention I suggest that you leave a little spot in the back of the suit so that the other men will not shoot the other men in the back.

"My other reason is on the other side of the paper and read the rest of the letter for me.

"I am a boy who is hated by everybody and have been so for 10 years and more so. That is since my brother was born in 1934, he is the most liked by everybody. I am not getting good ranks in my school work and eaven my mother and father and brother hate me. I can't go down to the movies without getting into trouble with the kids. Could you work with people who hate you all the time in school, home, and at work, also. You may think I am crazy but this letter is the truth as I know it to be. I am on probation for running away from home 4 times, and I like heavy work and you."

Ideas have come to the Council from many sources. Two good ones, for instance, came from Hollywood, sent in respectively by a glamorous star and a celebrated actor. Thousands more come from farms, garages, attic and basement workshops. These ideas prove once again, if that is necessary, the inventive genius of Americans.

A doctor, family style, is responsible for the war time stuffing of the bosomy Mae West jackets which have kept American airmen and sailors afloat when their craft have gone down at sea. When the Japanese took the Dutch East

Indies they shut off the American supply of Java kapok—the standard, and up to then, the best filler material for life belts. The Government took stock of the precious material. There were exactly seventeen million pounds on hand—enough to meet the nation's general needs, five million pounds for the next three years. Actually, it was a supply on paper only. The kapok was baled, and being a vegetable fiber would deteriorate rapidly under the high pressure of baling and would not be safe to use.

Kapok, or Bombax cotton, is floss from kapok trees, and the best of it grows in Java. Sources of poorer quality floss such as the East Indies, Ceylon and British India were also cut off by the war. Kapok supplies from Central and parts of South America were negligible, and there didn't seem to be much that could be done about increasing shipments from these parts. The kapok tree takes six to eight years to mature; it is not a prolific bearer; is easily damaged and must be picked by hand. And only about ten per cent of all the kapok trees formerly producing the world's supply were cultivated; the rest grew wild.

Now our story goes back to the days when Okies were fleeing the dustbowls of the Middle West. At that time one Dr. Boris Berkman, a Russian-born physician practicing in Chicago, who held degrees from the medical schools of Leipzig, Krakow, Prague, Munich, Vienna and Moscow, put his hobby of botany to work. He disagreed with the current theory that the planting of trees would halt future erosions and began looking around for a faster-growing, more prolific plant whose roots would hold the soil down. He finally settled on that roadside weed and farmer's pest, milkweed. The roots of the plant spread out and matted under the surface, and there was no doubt that it was prolific, for its seeds, clustered together by the thousands in their pods, needed only a few dry days of early fall to be released to the winds for distribution.

Dr. Berkman's scientific interest in the weed grew quickly. From its sap, stalks, leaves, pods and roots he developed everything from a latex to animal fodder. From its beautiful silky floss, he spun thread and wove cloth. When all the world but America went to war, and the kapok crisis arrived, he took some samples of milkweed floss to Washington and stopped in at the National Inventors' Council to see what they thought of it as a substitute. They thought enough of it to point out the way for him through Army, Navy and government channels. Showing the result of hundreds of tests, the doctor finally convinced the Army, Navy, Department of Agriculture and the Defense Plant Corporation, that he had something. The result was a million-pound capacity milkweed processing plant built by the Defense Plant Corporation at Petoskey, Michigan, which was picked as the site because bigger and better weeds grow in the vicinity.

After Pearl Harbor, Dr. Berkman gave up his medical practice to devote his entire time to the production of the lifebelt material and to further milkweed research. He found it possible to heat the plant during the fuel shortage of 1944 by burning the dried pods of the weed. Right now farmers in the vicinity of the plant, who formerly despised the weed, are cultivating it; and, until such time as these cultivated crops meet the demand, school children are being asked by the Department of Agriculture to gather milkweed pods as they ripen in the fields and roadsides. Whether the United States will ever go back to kapok as lifebelt filler is highly doubtful. The milkweed floss has proved far superior to it in almost every instance. For one thing, it can be separated mechanically, which reduces the amount of foreign matter content to one per cent; and a Mae West jacket using two and a half pounds of milkweed floss as against three pounds of kapok will support, even in stormy waters, seven more pounds of humanity; and in calm water will keep a man afloat from forty-one to forty-four days.

Once down, whether it be in the sea, or in jungle or desert, the survivor's most urgent necessity is potable water. Without it, he can live for, at the most, ten days. With as little as two ounces a day he can exist for two weeks or a little longer, even if he has virtually nothing in the way of food. Ideas for making salt and brackish water potable have been many and varied. A former Governor of Pennsylvania, Gifford Pinchot, not so long ago announced a method for extracting a drinkable fluid from fish; which would seem at first glance a godsend for men down at sea in lifeboats and rafts. But it turned out that there was no means available to arrange to squeeze water from fish on rafts or lifeboats.

The Navy from the very beginning of the war set about trying to devise simple, efficient and portable stills and salt water converters. With the help of the Council, the Navy carried on a continuing research, for the limitations of life rafts require the utmost simplification of all equipment. And today, the very latest in salt water stills for both Army and Navy fliers is a pocket-sized, vinyl-plastic envelope, which uses the sun's rays as fuel. The envelope when unfolded is blown up and floated and a black cellophane sponge, stretched through the middle of the envelope, soaks up water, and through evaporation and distillation by heat from the sun, the salt is taken out of sea water.

Soldiers in the field are constantly devising improvements, weapons and safety methods. A British trooper, for instance, sent in a good idea for a hawser with which a tank can be pulled out of a ditch or tank trap under its own power.

It is interesting to examine a list of problems set before the public by the National Inventors' Council early in the war, and then to examine a later list, issued some two years after the first.

The early list asked for fourteen definite protective devices out of a total of fifty-five problems:

Ionic exchange methods for the removal of dissolved mineral matter from sea or brackish water in which the ratio of mineral parts to water is in excess of 4 to 1,000.

Means of controlling fires in fighting tanks for a sufficient period of time to evacuate personnel. The process should not be injurious to personnel and should be manually controlled and operated. These are large ammunition fires wherein the oxygen to sustain combustion is self-contained.

Reduction of reflection from glass surfaces by durable coatings suitable for field application. Reflection is one of the most common ways of giving away position of our troops and equipment to enemy observers.

A simple non-toxic process for darkening aluminum and other metals suitable for kitchen utensils, such as the insides of cook pots whose reflections often give away the position of field kitchens.

Methods of protecting our vehicles from the effects of enemy land mines.

Clothing giving protection against falling pieces of white phosphorus.

Protection against flame throwers. The wire mesh screens commonly suggested are ineffective against modern flame throwers.

Design of life vest which automatically inflates and turns the man on his back when he is thrown overboard by concussion and is unconscious.

Methods of insuring CO_2 inflation of life rafts within 30 seconds' time at temperature of 20 to 40 degrees Fahrenheit.

Now glance at the latest list of military and naval problems submitted by the Council:

1. *A satisfactory shock-proof aerial delivery container* not requiring a parachute; possibly pneumatic cushioned, the cushions to be inflated from a CO_2 bottle after leaving the plane. Inexpensive enough to warrant its being classed as expendable after being used once.

2. *A beach marker light,* to be visible from 5,000 yards out to sea with rechargeable or non-deteriorating battery. Not in excess of five pounds weight. Effective burning time: 70 hours' continuous use, or seven days of twelve hours on-twelve hours off use.

3. *Device for transmitting rotary motion through a moisture-proof barrier.*

Applications: Shafts for control knobs on radio equipment provided with immersion-proof case; generator shaft for field telephones equipped with immersion-proof cases; generator shafts for hand-cranked power supplies for field radio equipment.

Characteristics: Should prevent entrance of water or moisture vapor when immersed to a depth of ten feet; should offer a minimum of frictional opposition to rotary motion; should be small in relation to the equipments to which applied; should have ample power transmission capability; should be applicable to existing equipment with a minimum of modification.

4. *Waterproof Jack.*

Applications: Microphone, headphone, and key jacks for telephone equipment.

Characteristics: Should prevent water or moisture vapor from penetrating equipment, even when immersed to a depth of ten feet; should be capable of cleaning and drying without tools; should accommodate standard plugs.

5. *A durable plastic-impregnated fabric,* waterproof, lightproof, weighing less than six ounces per square foot. Suitable for tentage.

6. *A gasoline resistant coating* for the interior of gasoline drums and not adversely affected by gasoline.

7. *An oil or liquid knapsack sprayer* for use especially in malaria control work in overseas theaters, which (a) is of simple construction, (b) has easily replaceable and reproducible parts, (c) has a minimum of rubber parts and gaskets, and (d) is light, rugged, durable and leakproof.

8. *Proofing material* which will make tentage and tarpaulin more resistant to the rapid rotting that now occurs in humid, tropical climates.

9. *Directional-Drum Lens.* The Coast Guard uses a large quantity of 200 mm. fresnel type drum lenses on lighted aids to navigation. These lenses provide a 360° fan beam of uniform candlepower about the horizon. In many instances the candlepower in a specific direction should be considerably higher than that of the uniform beam. Present practice in such cases is to install an auxiliary "spot" light to increase the intensity in the specific direction.

A need exists for a single lens which will permit the function of both of the above lights to be accomplished from a single light source. The lens should have the overall dimensions of the present 200 mm. drum lens to permit its being used in the existing housings.

10. *Single Unit Range Light:* A single optical device

which will indicate with a reasonable degree of sensitivity a vessel's lateral deviation from the centerline as it proceeds along a narrow channel. Such a device must be inexpensive and low in power consumption. The conventional aid to navigation for such purposes consists of two lights on the prolongation of the centerline separated some distance from each other with the rear light higher than the front. It is in the interests of economy, and also to provide against the fact that the terrain may make the installation of two lights impractical, that this device is needed. Economy involves current consumption and cost of structures. Existing two-light ranges require approximately 50 KWH per year for a candlepower of 10,000 white.

11. *A portable fire extinguisher* using liquid similar to the carbontetrachloride (or Pyrene) type, suitable for use around electrical equipment which will not form phosgene or other toxic gas when used to extinguish fires, as is the case with the carbontetrachloride extinguishers.

12. *A continuous sampling combustible gas indicator* with automatic alarm which is simple, positive, inexpensive and suitable for installation in gasoline-driven motor boats for continuous sampling of the vapor in the bilges.

13. *A polyphase AC integral HP motor* up to 50 HP, whose inrush current does not exceed the running current and whose starting torque equals the running torque.

14. *A small portable field strength meter* about the size and weight of a walkie-talkie for rapid checking of radio field intensities in the vicinity of radio transmitting stations. The instrument must be simple to secure and accurate within plus or minus ten per cent. Frequency range desired is 100 KC to 20,000 KC. The range of field intensities desired is from 10 to 1,000 millivolts per meter.

15. *Radio Antennas* up to 300 feet in height that can be set up by unskilled ground crews. The efficiency of radio devices is often limited by the extreme difficulty of obtaining reasonable antenna heights quickly in the field. Very light alloys and special rigs for rapid erection by a ground crew without climbing are desired, in addition to ability to dismantle or collapse into packages not exceeding twenty feet in length. Insulated base vertical antennas are preferable but grounded base type could be used if the device had enough other advantages in the way of ease of erection and ruggedness.

16. *A cheap and effective barrier* to prevent the propagation of cracks in steel structures, without making use of riveted seams and the caulking, etc., incidental thereto.

17. *A method of welding high pressure piping* without the aid of backing straps or with back straps which would be soluble in a harmless solution which could be introduced in the pipe before putting same into service.

18. *A method of measuring the elastic stresses* locked up in steel or other metallic structures at and beneath the surface of the material without having to dissect the structure in order to record the elastic recovery which results from isolating various segments.

19. *A method of welding light gauge aluminum.* (This is of particular interest since aluminum lifeboats and life rafts are currently of riveted construction due to the lack of a satisfactory method of welding.)

20. *A "non-slipping" shoe sole* which will give good footing on an oily, steel deck of a ship rolling as much as seventeen degrees. This shoe sole should be non-injurious to feet, non-sparkling and reasonably long wearing.

21. *Small aircraft type D.C. motors* without commutators, slip rings, or any other moving contact arrangements,

to eliminate service difficulties with commutators and electrical noise produced thereby.

22. *A precision twin-triode vacuum tube* with general characteristics of the current 6SN7 type having the following additional precision features:

a. After a fifteen minute warm-up, the gm of the two sides shall be equal over the normal operating range to within plus one per cent.

b. The tube shall be completely nonmicrophonic.

c. The above characteristics to be maintained over an ambient temperature range plus 89 degrees C. to minus 40 degrees C.

d. It should be possible to produce this tube by mass production methods with not more than ten per cent rejects.

Note—Tubes presently available in production permit excessive variation in grid-plate conductance in the separate halves of the tube.

23. *A small Hooke's joint or Universal joint for instrument use,* the efficiency of which is sensibly constant with angularity of output shaft axis up to ten degrees. For above shaft axis angularity units, the Hooke's joint should have an angular velocity ratio of input to output shafts constant and equal to unity over the cycle with as high an efficiency as possible.

24. *An expendable, compact, lightweight, rugged, mechanical device* to permit successive closure of up to eight electrical circuits with a time interval between closures of about 0.2 to 0.3 seconds.

25. *A small, fast-acting, double-action solenoid* to operate on 28 volts D.C., with a stroke of about 0.5, with a 20 pound pull (or push) at condition of maximum air gap. The plunger should "seat" at each end of travel and

would very probably have to be an electromagnet whose polarity would reverse at each end of travel.

11. Body Armor

THE AIR FORCE didn't want helmets. No tin pots for the Army eagles, they said. So Ordnance, which had submitted a basic design for steel helmets for air crews personnel, went ahead with their big job of restyling and redesigning the dish basins of World War I to the slightly Prussian-looking, dull green, steel head-armor which American ground troops wear today.

Then the 8th Army Air Force, in 1943, started flying out for Germany from new bases in England. They flew the early B-17's—the big armor-plated Army bombers—and took them up in daylight raids over the Reich; in mass formations, remember, of 500 and 600 and 1,000 planes. The daily papers carried big headlines: 750 U. S. Planes Blitz Germany. But the news report would reveal the fact that 75 ships had been lost over the Reich.

What was wrong? everyone asked. Why were we losing so many planes and men? What was wrong with American ingenuity? We could train the best fliers in the history of aviation; build the best planes in the world; equip them with Norden bombsights which practically eliminated the "miss"; put great throbbing engines on them that carried them half across Europe to lay retribution on Hitler's doorstep; and then they were shot out of the air like pigeons by German fighter planes.

The matter was twofold. To begin with, the big bombers' fighting plane protectors could follow them only so far on their raids. The fighters weren't built for long cruises, so that the last and worst half of the flight was without fighter escorts. That left the B-17's wide open to the German planes that buzzed up from the menaced cities of the Reich like a swarm of enraged hornets whose stingers were cannon that fired 20 mm. shells.

The cannon were doing the damage. Their big shells were tearing through the armor plate of the B-17's. They were not only going through the plate but as they cleared it they started to swell and bits of steel skin peeled back. With complete clearance, the elasticity of the steel case was reached and the shell detonated, scattering jagged bits of shell case or flak within the plane.

Flak wounds are messy even when they are not particularly harmful. The ragged edges of the steel fragments gouge and tear the flesh, and smaller bits bury themselves deep within the wounds. But a wound on a fleshy area of the body can, in most cases, be patched up. The same wound on the head is fatal nine times out of ten.

The crews of the 8th Army Air Force began to beg, borrow and swipe steel headgear from their compatriots in the ground forces. But the helmets were not right for airmen. The steel sides that came down over the ears and which gave necessary protection to the sides of the head for infantrymen interfered with airmen's earphones. Soon Ordnance, which had been more or less sharply rebuffed for its earlier foresightedness, received a directive from 8th Army Air Force headquarters in England.

"Send us steel helmets," the directive said, in effect. "Helmets with flap sides permitting the use of earphones. Send them tomorrow."

Ordnance couldn't send them tomorrow, or the day after, either. As a matter of fact it would take exactly eight months, and eight months was the minimum, before the design could be drawn up, molds made and the helmets started on production. So Ordnance did the next best thing. It rounded up a few thousand infantry-type headgear, set them up in special vises and sawed off the sides. The makeshifts filled the bill, temporarily and well. By the time the specially designed air crew helmets were a part of standard equipment, the loss of planes during raids over the Reich became negligible.

The makeshift helmets did another thing. They made the air forces armor-conscious. Crews which had scoffed at the idea of tin pots for eagles were careful to remember to carry their helmets with them on missions. The steel headpieces were hot, heavy and uncomfortable, and more often than not they were tossed on the floor of the plane to be kicked around, or crammed into corners out of the way. But at the first puff of flak they were quickly rammed on before the crew went into action. Even when German opposition slackened and a squadron off on a mission were fairly confident of running into only the slightest fighter defense or anti-aircraft flak, the airmen felt superstitious about leaving their helmets behind.

There is the story of the two first lieutenants, both of whom happened to be named Paul, which any air force member can tell you:

One of the lieutenants was a navigator and the other was the bombardier on a B-17 of the 15th Air Force. They were on a mission against the Rumanian oil refineries at Ploesti and were getting into the flak belt when Paul, the bombardier, half turned his head and called back to the navigator:

"Hey, Paul, hand me a flak helmet."

It wasn't forthcoming right away, so the bombardier turned full around and looked at Paul, the navigator, who had a look of complete amazement on his face.

"Where the hell is that helmet?" the bombardier asked.

Paul, the navigator, still looking bewildered, but saying nothing, handed it up.

They went through the flak, and it was heavy. They dropped their bombs, withdrew from the target, and when the sky was growing peaceful Paul, the bombardier, turned around again and looked at the navigator. Paul, the navigator, was sitting there bareheaded.

"Say, Paul, why didn't you put your helmet on?" the bombardier asked.

"There was only one back here," said Paul, the navigator.

Ordnance developed two types of steel helmets for the combat crews of the Air Forces. Everyone except a turret gunner wears the M-3. This type fits over the regular leather flying helmet. It has projecting steel flaps to cover the earphones and the flaps are held in place by a chin strap. A coating of flock, a substance similar to cotton lint, is applied to the metal to prevent the fliers' bare hands freezing to it in the extremely low temperatures of high altitude flying. But Ordnance had to develop a special model, the M-4, for turret gunners because the limited space in a turret makes it physically impossible to wear a regulation steel headpiece. So the M-4 is made of steel plates, shaped to fit the contours of the head and enclosed in a canvas cover.

The helmet of World War II has done more to cut down front line mortality, both on the ground and in the air, than any other single piece of equipment. The most vulnerable part of the body in war is always the part that is most often projected, and a man's head leads the list of projected parts. The jaunty-looking, basin-shaped tin hat of World War I was very shortly discovered to give little more than nominal protection. But in 1917 we had adopted its design and production methods from the British, and World War I ended before a helmet of better design, which had already been devised, could be put into production. However, the prototype of the Germanic-looking improved steel helmets which we see today had been rather thoroughly worked out, so that by 1941, when the conscriptees threw away their broomsticks for guns, they were also issued the new type head armor.

A soldier and his helmet are not easily parted. Generally he'll wear the separate leather lining designed to be a head covering as well, and carry the steel case. But a helmet, heavy and cumbersome as it is, imparts a psychological satisfaction to a man. It's comforting to know that a sturdy piece of steel can be set between his brains and an enemy's bullet, though actually even the modern steel helmet is not 100 per cent effective against every missile.

Unhandy as it is to carry, except by wearing it, a helmet's usefulness when a GI falls out for bivouac or a respite is infinite. Eggs and wayside poultry have been boiled in them; water carried; beards shaved; dirty socks and singlets washed; all because a helmet came in handy.

The use of body armor in modern warfare is limited. It can be worn only by fighters who go into combat in more or less static positions. That's why the infantryman wears only a steel helmet in the way of defense, while airmen, who are relatively immobile at their combat positions, can and do wear flak suits, shawls and blankets—which are modern names for cuirasses and coats of mail.

Actually there is nothing even relatively new about the flak suits and protectors worn by American airmen. The basic principle of flak suits was developed in 1921 by Army Ordnance. And Ordnance was only carrying on an age-old battle between armorers and weapons. Body armor is an apparatus for defense in war. The armorers of Etrusca, Assyria and Rome contrived shields, breastplates, helmets and greaves of metal for their fighting men which warded off the arrows, pikes and swords of their enemies. The old Germanic tribes used shields of willow wands overlaid with leather or wood. Finally by the Middle Ages, when the horse had become a standard war machine whose speed increased the impetus of the blow of pike and lance, the chain mail of the earlier centuries gave way to plate armor and the armorer lost a round to the maker of weapons, he had to sacrifice weight in order to gain adequate protection. And the horse, which not only bore a heavily armored rider had, in addition, to wear a suit of plate armor itself which sometimes weighed as much as eighty pounds. The war horse thus became a heavier type animal—like the modern brewery horse of today—and the rider was so heavily encased in armor plate that he had to be fairly lifted onto his great steed and sent into battle in a more or less fixed position. Once unhorsed he was practically a dead duck.

With the advent of firearms on the battlefields of the seventeenth century the armorer's day was done. The weight of protective clothing against the increasing art of the munition maker became prohibitive and body armor fell into disuse except for the purely dress parade breastplates of a few European regiments. World War I saw the reintroduction of defensive armor to some extent. All belligerents used steel helmets, and, against snipers and bombers, some few steel shields were used, while the Germans were discovered to be wearing bullet-proof jackets, or cuirasses to use their ancient name, similar to that of Oliver Cromwell's pikemen.

When the Ordnance Department of the United States Army went into the business of devising protective clothing for airmen (and plate armor to cover the abdomen, groin and thighs of sappers) it started out from the very beginning. The curator of the New York Museum of Art was called in and acted as consultant on research. Every type of armor ever used by man was carefully gone over for any little device dreamed up by medieval fighters which might possibly fit the needs of modern warfare.

Yet the modern flak suit bears little resemblance to its ancient prototype. At first glance it looks like a double front and back apron of quilted canvas. But between its two layers of canvas are small quarter-inch thick plates of steel. The front and back pieces of the flak suit are gripped together at the shoulders by large snap fasteners and the sides are held together by an ingenious lace fastener. The flak suit is worn over the complete flying uniform, including parachute harness. But the parachute itself must be left off. The lace side fasteners of the flak suit are accordingly so arranged that at a tug on the lace, the flak suit drops completely off, allowing for a quick hooking on of the parachute.

The flak shawl doesn't bear much resemblance to knightly armor, either. It is shaped like a horse collar and is worn around the neck to protect that vital area. While flak curtains of steel lined canvas, which are not strictly body armor, are used by plane crews to screen off vulnerable parts of the ship.

The flak suit which is now standard equipment for American airmen is the fourth model to be developed, since Brigadier General Malcolm C. Grow, then Surgeon of the 8th Air Force, overcame the last of the 8th's resistance to body armor and introduced the innovation. There undoubtedly will be later models for improvisations, additions and suggestions constantly pour in from fliers themselves, most of them favoring tailpieces and armored seats.

Spent bullets and low-velocity shell fragments were originally responsible for 85 per cent of all casualties in air combat. A recent analysis of the experience of 133 airmen struck by flak or other sorts of enemy missiles while wearing body armor showed that two-thirds escaped injury of any kind; 24 per cent were slightly wounded, and 10.5 per cent were killed or seriously wounded. While an accompanying study of injuries received by members of plane crews who had not worn flak suits disclosed a substantially higher percentage of serious injuries.

But closer to the heart than dry analysis is the word of mouth advertising a waist gunner who formerly disdained the flak helmets which Ordnance cunningly devised with ears flaps and neck shaped to fit against the fur collar of his flying jacket gives: "I thought it was sort of foolish to wear a flak helmet because of the weight and trouble, and I didn't even take one along with me. It was fortunate that my radio operator had two helmets with him, one flak and one ordinary steel helmet. He insisted that I put his flak helmet on and wear it, so I did, and he wore the steel one. . . . We had unloaded our bombs over Berlin and I saw a concentration of flak outside the window. We were heading for home, going toward Denmark, and the next thing I knew it felt like someone hit me on the head with a sledge hammer. A piece of flak two inches long and a half inch wide struck my helmet about two inches above the rim and directly over my left eye. . . . I had a severe headache. The helmet saved my life. . . ."

While another, more cautious waist gunner told his flight surgeon: "On my twenty-fifth mission I was hit by two large pieces of flak directly over the heart. The flak was deflected, although the force of the blow knocked me backward into the left waist gun position, and knocked me down as well. I received no injuries except mild bruises of the chest. Two plates of the flak suit were bent considerably by the blow and one later fell out and was lost. I advise everyone to wear flak suits."

The flight surgeon who had examined him said that he had been saved a probably fatal chest wound by his body armor.

Or this pithy tribute from a tail gunner: "I'd hate like hell to go out without a flak suit. I was flying my regular tail gun position when I was hit . . . 13.9 mm. (machine gun) bullet pierced two stuts and the oxygen bottle above me. Coming down on a vertical plane, it penetrated my flak suit and went through the soft tissues above the bone of my right shoulder. If it weren't for the flak suit the bullet most likely would have continued straight on through my lung. . . ."

12. The Rescue of Men

ONE BRANCH of the Navy's Air-Sea Rescue organization, the Dumbos, has licked that old devil sea so effectively that Navy men are already telling Dumbo tall stories. The latest one concerns the downed Army flier adrift on a raft who was spotted by a Navy PBY rescue pane. The man did not respond with the usual greeting of a survivor adrift on the open sea, but the PBY crew knew he was alive: they could see him working with something in the water. The rescue plane landed and taxied toward the raft. But the man motioned them away and made signs for them to be quiet. Thinking that the poor creature must be suffering from shock, the plane drew alongside the raft. The man grew highly indignant, and for the first time the rescuers noted that he was using his emergency fishing kit. He had already landed one fish and was after something really big. He preferred not to be rescued just then, he told the PBY, if they didn't mind. He'd wait for the next Dumbo.

We have reached the point where jokes can be made about survival and rescue in the war. It wasn't always that way. In 1942 the chances of survival on the open sea in an open boat were so slim that the heroic exploits of men like Harold Dixon, Gene Aldrich and Tony Pastula, the Navy fliers who fought the sea for thirty-four days, were made into a popular book, "The Raft." And the nation, which had mourned Captain Eddie Rickenbacker as lost when his plane was reported overdue from a sea hop, followed with bated breath the published account of his battle against the sea and the miraculous answer to his prayers which sent a lone gull to his raft. Other men, less well known perhaps, but just as hardy, lived to tell of dreadful experiences. Michael Wajda, electrician's mate of a torpedoed merchantman. drifted for forty-six days on a life raft, saw two companions die and buried them at sea, made a net of twine and ate the fish he caught with it, squeezed out rain water from a quarantine flag and drank it before his raft grounded ashore on British Guiana.

But these were exceptions rather than the rule. Other lifeboats drifted up against our own shores like seagoing coffins carrying a cargo of pitiful dead. Planes went out on missions and never returned; their crews were marked first as missing, then as dead; merchantmen were torpedoed leaving nothing but an oil slick and some shattered pieces of driftwood which might at one time have been lifeboats. America woke up to the fact that she was fighting more than Japanese and Germans: the sea also was an enemy. And as the war fronts widened, jungles, deserts, arctic and mountain added their peril to the sea's.

Dumbo service really started before the war in Honolulu. A Navy pilot coming down at sea in a forced landing radioed his position back to base. But there was no boat available to go out and pick him up. There were some Catalinas, the Navy's big armor-plated seaplanes, at the base, but the weather outside was rough and it was commonly supposed that the PBY's couldn't land in a heavy sea. However, a pilot volunteered to try, and things worked out surprisingly well.

Since the outbreak of war, the big, lumbering Consolidated Catalinas have been the Navy's jack-of-all-trades. They have done everything from ferrying gold braid to glide bombing the enemy's ships and shore installations. In the last days of the battle for Midway, they were the relief planes flown in to help the Midway Marine garrison: "The Commuter Command," their pilots called them; "out by sea and back by rubber boat." Wearing coats of ebony paint, they are the night-raiding Black Cats which have kept a whole Japanese army starving to death on the graveyard coast of northern New Guinea and made life hideous for enemy shipping trying to skulk by night along the islands of the South Pacific. As the Dumbos, they are now doing the bulk of the rescue work in the Pacific.

The PBY's are the nearest things to boats with wings this side of heaven.

In the sixteen years since the first Catalina left the drawing board, not much has been done to improve their looks, but all the gimmicks have been worked out of them. A good pilot can set a Cat down and take it off again from the angriest sea with all the nonchalance of a herring gull. And PBY pilots don't come any better than Pilot Officer Nathan Green Gordon. His "Arkansas Traveler" was one of the Black Cats keeping the death watch on that Japanese army interred in New Guinea. One day, early in MacArthur's campaign of island-hopping back to the Philippines, he was assigned to the unusual job of standing by for pick-up duty, while some medium Army bombers carried out a preliminary softening-up of Kavieng, the big Japanese stronghold on the northern tip of New Ireland. He took station on the outside of the fighting perimeter, hanging at about 2,000 feet, while his fighting escorts—four Thunderbolts—made slow rolls and S turns in order to stay with the slow moving Cat.

A strong west wind was kicking up a sea whose crests measured eighteen feet from trough to tip, and Gordon, looking down, hoped that he wouldn't have to go down for anybody. The first call came through from the Army base at Cape Gloucester, New Britain. A B-25 was down some forty miles off the coast of New Ireland. Goldon flew over the area designated, but couldn't find a thing. While he was still searching, a formation of B-25's passed overhead. His radio crackled: a B-25 was down; two of the homeward bound planes would lead him to the spot.

His guides turned in the direction of Kavieng. About two miles out in the surf from the Japanese stronghold itself, six men were clinging to a two-man raft. They were almost indistinguishable in the gray swirl of the sea, and Gordon dropped a couple of smoke flares to mark the spot. Then he circled to come in on the downhill side of a wave. The way to do it, he knew, was to set the Traveler down like a duck, tail-end first, and let the drag of the water slow his speed and lower the bow. But what happened was that one of those treacherous, mountainous waves reached up and smacked along the entire hull of the Traveler before Gordon had a chance to ease her down. The jolt not only jarred everyone's eyeteeth loose, but it sprung more rivets in the Cat's bottom than was healthy.

It was too late to count rivets, sprung or otherwise. The Traveler was down in that boiling water, and the next thing to be done was to get the six men, two of whom were obviously injured, aboard. While Gordon kept the props turning at their slowest, one of the crew tossed a line out to the raft. It was caught and secured. But even with his motors barely idling, the forward pull of the plane was too strong and threatened to drown the waterlogged Army fliers. There was nothing to do but cut the motors and let the raft come up to the Traveler. In the meantime, the Japanese were getting uncomfortably close with fire from their 20 mm. and 75 mm. shore guns. Another line was secured to the raft, it was drawn up to the PBY, and the tough job of hoisting the men out of the water was accomplished.

Three times more Gordon set the big Cat down in the water to pick up downed Army fliers. Each time the motors had to be cut, the enemy's bead grew more menacing, and the landing spots closer inshore. On the third landing the spot was marked, not by the orange oblong of a raft, but by a patch of crimson cast by the stain canisters of Mae Wests. What looked like a lone head bobbed up and down in the very center of the bright patch. The landing—it had to be just right because of the sprung plates—was accomplished in a cascade of spray kicked up by the Japanese tracer bullets. But what from the air had looked like a head was only the corner of a waterlogged AAF raft. The Japanese had strafed it, and the crimson dye that marked it was no redder than the blood that had been spilled.

Once more the "Arkansas Traveler" dipped down into the sea before she turned homeward. And when at last she turned back toward New Guinea, she carried sixteen, four of whom were badly injured, in addition to her own crew of five. Her protecting Thunderbolts had to leave before the third landing was finished; their gas was low. Only a lone B-25, dangerously low on gas itself, was left to guide her to the fourth pick-up, made right under the nose of the Japanese shore batteries, a quarter of a mile off the beach of Kavieng itself, and to hover over her on the long trek home.

But the cargo of rescued airmen was delivered safe, if not all sound, to the Navy base at Finschhafen, New Guinea. And none of the injured died.

A pilot goes down for any or all of several reasons. His engine may fail; he gets off course; the weather turns sour; fuel runs out, or the enemy may wing him. The very type of warfare we are fighting in the Pacific makes them happen more often there. But wherever a man is down, no stone is left unturned until he is rescued, or until the certainty of his death is established as possible. Even in those grim and bitter days of the early Guadalcanal campaign, the Navy sent J2F-4 sea planes, the little two-seater ducks, out to search the sea for plane crews overdue from a mission. But it was like sending a boy on a man's errand: a two-seater isn't much help when it comes to picking up the crew of, say, a Fortress.

The PBY's had asked for it. They had gone out, like Gordon's "Arkansas Traveler," and done things no plane or pilot should be able to do. It was only natural that the Navy should delegate to PBY's and PBY men the tasks of organized rescue.

To movie addicts, Dumbo means Walt Disney's silly little elephant who went on a spree. To Army and Navy combat fliers in the Pacific, Dumbo means what they yell for when a crash landing is imminent. And a Dumbo pilot is the guy whose entry into any officers' mess is hailed with shouts of: "Steak for the Dumbo pilot!" (He gets the steak, even if it happens to be the last one in the mess.) The name itself was the result of trigger-thinking on the part of an unknown operations officer, who had to devise a radio code name for the rescue planes a few minutes before a sortie. And though the code name has been changed a thousand times since—it is changed every day—Dumbo stuck.

Every big mission includes the Dumbos now. The big lumbering rescue planes are picked up by the fighters and bombers en route to the target and they trail along in the wake of the speedier combat planes to the fighting zone. Once there, they fly a slow, careful patrol of the perimeter of action searching for mishaps. No speed demons at best, and with all the flexibility of tightly corseted matrons, the Dumbos have to have fighter protection. Usually a fighter will be assigned to an individual Dumbo, which means hard work for the fighter pilot, as he has to keep his pace slowed down with the long looping turns and rolls, in order to stick with the rescue plane. The New Zealanders have been best at it, and thereby hangs a tale.

Right after the Army reached the Pacific, a group of New Zealand pilots showed up one day at an Army air base. They were pilots in search of planes. "What do you have that we can fly?" they asked the Army. The Army shook its head. "Nothing," was the answer. But the New Zealanders said: "How about those ships?" pointing to some discarded Warhawks. "They're crates," the Army said.

The planeless pilots might just as well have been from Missouri as from New Zealand. As far as they were concerned, planes and pilots who couldn't fly when mixed together and shaken well over the Pacific, came out meaning trouble for Japs. So they took over the Warhawks. The Warhawks and the Dumbos make a perfect combination. The Hawks are slow and fly best at low altitudes. Consequently they don't have to waste gas and try their pilots' patience to stay back with the PBY's. And so, on the Warhawk-equipped New Zealanders has fallen the task of looking after the mercy planes.

Sometimes a New Zealander comes back from a Dumbo-protecting mission with a more than slightly red face. At least one did. He had been watching over his charge with typical New Zealand thoroughness during one particularly hot raid when his engines failed and he came a cropper. Without even lighting a Murad, the Dumbo he was protecting nonchalantly settled its big bosom into the sea beside his downed plane and scooped him up.

A Dumbo assigned to rescue work in a big strike goes about its job of picking up downed airmen with all the absorption of an absent-minded professor whose nose is buried in a history of ancient Rome while he walks down Main Street in 1945. Flak, enemy fighters and every other obstacle mean nothing when Dumbo is following a winged plane down to the sea, or on its way down to pick up the occupants of a bobbing rubber boat. Sometimes they are shot up, but the amount of lead and punishment a Dumbo can take is miraculous. And very seldom is a rescue plane lost. Fighter and bomber pilots, if the Dumbo's own protection is not available, fly to the defense of the big Cats, like infuriated mother hens to the defense of menaced chicks.

Four 13th Air Force P-38 Lightnings were assigned as escorts for a Dumbo going out to pick up survivors of a Navy plane that had gone down off Ballale Island. The fighters flew to Ballale and stayed with the PBY while it landed. When the shore batteries opened fire, the P-38's strafed them, knocking out several. Because of the heavy fire, the PBY had to retire after picking up three survivors, but two of its crew and a lone survivor were left on a raft.

The Dumbo returned to its base, and a second rescue plane, also a PBY, went back to Ballale to pick up the three men still down at sea. The four Army planes had stayed with them, strafing the Japanese positions and diverting the enemy's attention from the raft. By the time the second Dumbo arrived the Lightnings were fresh out of ammunition. But the 13th Air Force pilots still stayed on. More diversion was needed while the second rescue plane went to work.

Circling like ducks in a shooting gallery above the Japanese gun positions, they deliberately exposed themselves as targets, while the Dumbo went hurriedly about its task of picking up the stranded Navy men. With empty guns they buzzed the area at 3,000 feet until the PBY took off with the three men and promptly headed for its home base.

All the fighter pilots escaped unscathed, though one of them had to make a crash landing after the left engine and hydraulic system of his plane was shot out. The other three planes, while also receiving hits from ack-ack, managed to make normal landings.

A few months ago, before the Army had completely neutralized Rabaul, a squadron of big and medium bombers was heading for the Japanese-infested spot on New Britain with a contingent of Dumbos plodding along behind trying to keep up with the combat planes. One of the Dumbos, coming out from a fleecy white cloud, saw two Zeros headed in his general direction, hell-bent for leather. Before the Dumbo man could do much more than figure he was a sure dead duck, a tight-flying formation of Army Liberators appeared as if by magic overhead. Talking about it afterward, one of the Cat's crew said: "It was funny, I had the odd sensation of imagining I could hear brakes screaming. The Japs are scared sick of Liberators' armament. One of the Zeros managed to get the hell out, but the other was too close—he was just blown clean apart. There wasn't a piece left big enough to write a letter on."

Sometimes, after big air battles, as many as fifty Dumbos will be sent out to pick up survivors. It's a purely practical procedure as well as being only what we would expect of a humanitarian nation. For pilots are valuable, more valuable in the air than in the water, or stranded on some coral atoll. And more often than not, when the Dumbos go out for survivors they often have to pick them up right off the enemy's front doorstep. After one particularly heavy raid on Rabaul, for instance, literally dozens of American airmen were floating around in the mouth of Rabaul's harbor—which at that time was the most formidable Japanese stronghold in the South Pacific. The Navy, setting about the job of getting them out of this very ticklish spot, sent bombers, fighters, submarines, destroyers and even cruisers to the scene. The submarines and destroyers waded right in beating up the Jap shore installations and ships; the cruisers stood off a little way and let everything loose; while overhead the fighters and bombers tore away at Jap planes and shore guns. In the midst of this melee, the Dumbos came in and, oblivious to the surrounding chaos, plopped themselves down on Mr. Hirohito's private harbor and started picking up American airmen right and left.

The weather ranks second only to the Japanese, in Dumbo estimation, as a trouble-making inconvenience in rescue hops. As a matter of fact, the Allied Nations have had a good deal of trouble from the weather in fighting this war. Japan sneaked up on Midway with perfect cooperation from the elements: a pea-soup fog shrouded their movements until they were right on top of the

Marine-manned island. Winter blizzards and the mud and rains of spring thaws didn't help much in the long grinding down of the Siegfried line. But in the South Pacific, weather, when it turns sour, is not merely bad; it's vicious. A tropical front is not content just to blow itself out. it must wreak a path of destruction, level every growing thing in its way, kill everything human that it can reach. That was the kind of weather which capsized and sank the three destroyers of the Leyte invasion armada. And it was that kind of weather which Lieutenant R. A. Melrose, USNR, ran into after taking his Catalina off from the Halavo base to look for the crew of a Liberator reported down at sea off the coast of Choiseul Island. This was during the early days of the Pacific campaign and there was no fighter escort available for Melrose. He ran into heavy rain squalls and a perilously low ceiling almost immediately after taking off in weather which even from the beginning didn't look too good. The area in which the Liberator was reported down is made up of a nest of small islands which, with the larger island of Rob Roy and the eastern tip of Choiseul, form a fairly well sheltered cove. But on the day that Melrose flew over it looking for the Liberator crew, the very center of the tropical front was concentrated on the area; wind and rain blotted out all visibility and there was nothing for the Catalina and the three Liberators which had joined the search to do but circle around the perimeter of the storm. When the front had lifted enough so that Melrose could make out the foam-wreathed outlines of the islands below, the Catalina resumed the search. Finally, five hours after taking off from Halavo, a Very's light was sighted from one of the smaller islands. Going down for a better look, Melrose saw three rafts and ten men on the beach.

The job of landing the big ship in the heavy seas without springing every seam in its hull was hard enough. But the struggle of the ten men ashore to launch the rafts and get through the mountainous surf piling up on shore was even tougher. Time after time, the attempt was made only to have the rafts picked up like so many chips and dashed back on the beach. When they finally made it, every man had been badly mauled, but every one of them was taken aboard the Catalina and returned to base.

At about this same stage of the Pacific war, a call came for a Catalina to take twenty-six wounded Marines from Enogai Inlet, New Georgia, to Halavo. The Catalina landed at Enogai about five o'clock one afternoon; loaded the fifteen stretcher cases and eleven walking wounded, and was about to take off, when two Zeros appeared from nowhere and started strafing runs on the Catalina. The big PBY was sitting like a tame duck on a pond burdened down with her load of wounded. But her crew manned her guns, the engines were started and the big plane started zigzagging crazily over the water trying to get out of the Japanese way. The Zeros were not to be outwitted. They came swooping down to within 200 feet of the Catalina, letting everything fly. On the second run, the PBY gunner took a 7.7 slug in the leg, and on the third try, the Japs raked the Catalina from stem to stern in a blistering fire. Flak from a 20 mm. shell caught the turret mechanic, and another 20 mm. exploded inside the bunk compartment, inflicting severe abdominal wounds on one of the stretcher cases. The Japs' fun was broken up when two Corsairs arrived on the scene and the Catalina went ahead with the business of taking off. But at 1,000 feet, her pilot discovered that the port engine was leaking oil badly. It was 5:30, the sudden tropical darkness would soon be on them and the risk of making a one-engine landing at Halavo with the heavy load of wounded aboard was too dangerous. The Catalina turned back to Enogai and settled down inside the inlet. It was just as well. The port oil tank was bone dry, and before a line could be snagged onto the flying boat from the attending Higgins, the big plane, with only her right engine turning, drifted onto a nearby reef. Her bottom was ripped open, and she began to take on water rapidly. By 9:30, the crew had bailed out enough so that the offending holes could be patched up and the Cat taxied over to the pier. Her wounded were taken off and returned to the Enogai sick bay.

Her crew worked all night patching up the ship and mending the bullet holes in wing tip float and oil cooler. They worked through an almost constant alert with Japanese planes buzzing down on nearby shipping. But at 10:25 the next morning the last drop of oil went into the tanks, the casualties were reloaded and the plane took off for Halavo.

On one occasion a report came into a Dumbo base that a transport pilot had spotted three men on a piece of wreckage off the coast of Guadalcanal. They were alive, because one of them had waved both arms in a frantic signal at the transport. No less than a lieutenant colonel rushed to the rescue. But he came back a few hours later definitely on the huffy side. He had spotted the wreckage all right. Three large pelicans were sitting on it. All three had waved at him. He hadn't waved back.

In the Pacific the Navy has the rescue technique down pat. As one Hellcat pilot remarked casually, on being fished out of the ocean for the third time, "It looks like I'm getting in a rut." Pilots in the briefing room before a big strike never fail to ask, "How about Dumbo?" And the answer always is: "There will be plenty of Dumbos. Don't forget to holler quick for them if you get into trouble."

Dumbo pilots deserve, and get, the best. In the beginning, however, conditions were hard. Quarters were generally a steel tender whose plates sizzled under the equatorial sun; officers' clubs were tents set up on the coral mud of some steaming island; communications were poor and there were no night landing facilities. But all that has changed for the better. Dumbo tenders are clean, comfortable; the food is good. The boys have all the conveniences as well as the comforts of home.

The Dumbos give the boys they pick up a special hat—a Dumbo hat, to be exact. And while no airman wants to go down just to earn one, when he does get one he wears it as a mark of esteem. One Marine pilot, as a matter of fact, doubly enchanted both by the good chow served at one North Solomons tender, and the idea of the Dumbo cap, refused to leave until the stock could be replenished and he could get one.

No airman in the Pacific—Army, Navy or Allied—begrudges the Dumbos their comforts. For the Dumbo men and planes are credited with rescuing and returning to duty more than two-thirds of crashed plane crews believed to have had any chance of survival.

Where the Dumbos leave off, the Navy's crash boats take over. They constitute another naval aviation arm, the ARB, or Aircraft Rescue Boats. While operating in a much more limited sphere than that of the mercy planes, their job is more complicated. They are responsible not only for the salvaging of the crews of downed planes, but for the planes as well, whenever possible.

The crash boats are English in origin. The British during their three-year-long blitz could ill afford either the loss of planes or airmen, and they started sending out small, fast motorboats to pick up the British casualties of the almost continual dogfights over the Channel.

When the Americans took over the idea, they made some innovations in boat design. Speed is the essence of rescue work in any case. In the matter of salvaging planes it is even more essential. Salt water ruins a plane in twelve hours. So the crash boats were designed primarily for speed. Their over-all length is 63 feet; they can get 37 knots out of the 650 horsepower Hall-Scott engine. But they give anything but comfort. ARB's hit the water so hard at top speed that their crews are not allowed forward below decks or in the crew's quarters when the boats are in motion. An ARB operating from an English base literally beat two crew members to pulp and unconsciousness when they were caught below decks and the captain, unaware of the fact, started out at full speed on an emergency run.

In addition to its crew of eight, a crash boat carries medical supplies, plasma and other emergency equipment for saving lives; a dinghy, two life rafts and tow lines. For defense, they are armed with two 50-calibre turret-mounted machine guns. And below decks are stored tommy guns, rifles, side arms and knives. They need it all.

A crash boat went to the rescue of the crew of a Catalina which had crashed into the sea after a wobbling take-off. Upon arrival the ARB found that the tail structure had sheared off when it hit the water, cutting off both feet of one of its crew. That man needed all the emergency medical equipment the crash boat carried; but before he would consent to be taken off the Catalina he insisted upon directing the rescuers to the other injured, calmly smoking a cigarette to sustain him. In spite of his bravery, two of the plane's crew drowned in the crash. Of the seven taken off by the ARB, all except the amputation case eventually returned to duty.

Like the Dumbos, the crash boats occasionally have their lighter moments. A commander once used an ARB as transportation to a nearby island where he wished to visit. He insisted upon having the dinghy to row ashore in, though the crew tried every means at their disposal to dissuade him. Finally, they lowered the small boat, the commander got in and the crash boat pulled away on another mission. Halfway to the beach a wind came up, kicking up a nasty surf and capsizing the redoubtable commander.

Some time after the blow had subsided the crash boat returned to the island to pick him up. They had the devil's own time locating him, but finally saw a fire at one point on the beach. Running close inshore, they spied the commander—stark naked, chewing on a piece of taro and quite chilly. Some close-fisted natives had driven a hard bargain with him: for the taro and matches with which to light the fire he had had to surrender his clothes.

A blimp under the command of Ensign Lowell E. Buys made the first sea-to-air rescue in the history of aviation. This is how it happened. On a routine patrol flight off the coast of California, the engine of Marine Pilot Harvey Metcalf's Avenger began to act up. He lost altitude rapidly and was skimming over the top of the water trying to nurse the plane back to shore when a large wave reached up and slapped him down. In the resultant crash Metcalf was injured. He and his gunner, however, succeeded in dragging out the plane's life raft and inflating it, while the other planes in the formation flew off to contact Buy's blimp.

The blimp raced to the scene of the disaster. A first-aid kit was dropped for the wounded flier and then a smoke flare to determine the wind direction. But the breeze was erratic and made it difficult for the lighter-than-air craft to maneuver over the raft. Buy brought the blimp down to within 25 feet of the raft. He could see that the pilot was in bad shape and would have to be taken to a hospital in short order. He ordered a crewman to lower a parachute harness on the end of a rope to the raft. The plane gunner fitted it over the shoulders of his injured skipper, the slack was taken up and Buys rose to above 75 feet as the injured flier was hauled up hand over hand to the blimp.

The actual time of getting Metcalf from the raft into the blimp was only twenty seconds. Within ninety minutes of the time he had crashed, the Marine pilot was deposited in a hospital bed.

The Government has no ribbons for the civilian heroes of this war. If it had, William W. Moss, Jr., of Providence, Rhode Island, a Pan-American pilot flying supplies to combat bases for the Navy, would have a chestful. On a day in 1943, seeking shelter from a tropical front, Moss brought his big Navy Mariner down in the tiny bay of an island outpost in the Pacific. He was met at the dock by an anxious lieutenant commander. Word had just reached the outpost that the Army transport, *Cape San Juan,* with 1,429 men aboard, had been torpedoed by a Japanese submarine three hundred miles off the coast. The nearest ship was hours away and would have to wait for naval protection before going into the vicinity of the submarine. The seas were running fifteen feet high. Rain was pouring down in torrents. The wind was blowing in tornado gusts and great flashes of lightning were crackling from sky to sea.

It looked hopeless for the soldiers. The last radio report had said the ship was going down fast, and that most of the troops had taken to the water. With that many men, the lieutenant commander told Moss, there wouldn't be enough life rafts and boats to take care of them all. And in the raging sea, those unfortunates who had to depend on Mae Wests wouldn't last long. What was needed was someone who could get there the quickest with the mostest: someone, maybe, who could pick up the most helpless of the survivors.

Moss cast a quick glance at the storm he'd run away from, and then he turned to the lieutenant commander and volunteered to go out there. He said to his crew: "I'm not ordering anyone to go. The weather's foul. We'll be lucky if we can find the ship. Even if we do find it, the Navy tells me the seas are running twelve to fifteen feet out there, and I've never set one of these tubs down in that kind of water. If we do get down in one piece, remember we still have to get back in the air. I've asked permission to go. If any of you—"

Even though the entire crew stepped forward, Moss didn't take them all. Some of them had to be left behind to lighten the load and to make room for rescue equipment. The Mariner was unloaded of its cargo in record time. Everything was stripped from the cabin except those things essential to running the ship, and it was filled with rubber rafts, life jackets, rolls of rope, blankets, medical aids, thermos jugs of hot soup and several quarts of brandy.

Then the Mariner took off. Moss coaxed the plane through rain and lightning and fought gusts of wind that whirled the big ship around like a dead leaf. The crew had to strap themselves to the braces while they readied the life rafts, tied life rings onto the ends of heaving lines, and cut lengths of rope for lashing the survivors to the deck. Within ten miles of the sinking ship's position, the storm broke suddenly. Dead ahead was the *San Juan*. She lay far over on her side like a wounded animal with only her stern sticking out of the water. As the Mariner swooped over her, a handful of men were seen clinging to the ship's overhang.

There should be more than just these few survivors, Moss thought. He took the Mariner upstairs in order to scour the surrounding sea. Five miles away an oil slick made an iridescent patch upon the heaving waters. The Mariner headed for it.

The oil had spread for three miles along the water. It was dotted like a currant bun with the heads of men. The Mariner spiraled downward on the outside of the slick looking for a likely crest to settle down on. Moss had told the truth when he had said to the crew on leaving the outpost that he had never brought a plane down on a sea like this. On the way out he had read over and over again the brief reports of two Pan-American pilots who had made emergency landings and had carefully coached the crew on the procedure they were to follow once the plane was down. But the boiling water under him bore no slightest resemblance to the diagrams he had studied so intently. He had no Navy "seaman's eye" to gauge the crests.

He finally picked a likely looking swell working up to a fifteen-foot crest and set the hull of the plane down on it. Wave and ship met in a crashing kiss that sent the plane hurtling up into the air again. Six more times Moss tried to set the Mariner down; each time the sea vomited it back into the air. On the eighth try, Moss hit the crest of a wave at exactly the right time between uphill and downhill surge, and the water caught the flying boat in a mad whirl that sent it teetering from crest to trough so madly that two members of the crew were prostrated with violent seasickness.

Even at that Moss managed to maneuver the plane through the water to the patches of bobbing heads. Three of the crew lashed themselves to the braces at the open cargo hatch and began throwing out life lines.

The almost complete exhaustion of the men after ten hours' immersion, and the slippery slime of the all-pervading oil, made it almost impossible for the soldiers to grasp the lines. And when at long last the first survivor was hauled up to the hatch, it took a whole half hour to get him out of the water into the plane.

Finally it was decided to tie an inflated, weighted raft at the end of a line and let it out on the water, much in the manner that an angler trolls for bluefish. With the rafts as bait, Moss maneuvered the plane past the clots of men struggling in the water. Raftloads of five or six survivors were pulled up to the plane and dragged on board —no easy accomplishment itself, since the swells would raise the raft to hatch level, one instant, only to drop it ten to fifteen feet below it in the next. But finally forty-eight survivors were loaded aboard the Mariner. Most of them had abandoned ship so hurriedly that they were in full battle dress, even to helmets. Once aboard, they were stripped to the skin and their equipment thrown overboard to lighten the plane's load as much as possible.

Only those soldiers who were helpless had been taken on. The crew of the Mariner had quickly learned to spot the helpless ones: those with their shoulders above water were riding pieces of wreckage; those who formed a rectangle in the water had a raft to cling to.

The Mariner had been at the scene two hours and the forty-eighth survivor had just been dragged on board when two bombers of the Royal New Zealand Air Force hove over the horizon. They raced up to the seaplane and dropped two Very shells. In back of the bombers a squall dropped a black curtain of rain. It was a double warning: the red fire of the Verys meant danger—probably the Japanese submarine coming back to the scene of its crime. The rain squall meant that the Mariner would never get up again—carrying twice its capacity as it was—if it hit them while the plane was still in the water.

The crew was ordered on the double to their flying stations; the wounded were distributed about the plane to get the best weight placement. The Mariner started out across the hills and valleys of the sea on a long taxiing roller coaster take-off. Before flying speed had been reached, a wave caught the plane and threw it up in the air. It fell back into the sea again, was caught and thrown up by two successive waves. The third blow from the Pacific sent the Mariner hurtling a hundred feet into the air, where her motors caught on, and the heavily laden ship took to her own element.

The ride back was no better than the one out. The squall caught up with them and sent jagged strikes of lightning down on every side. Torrential rains hammered at the strained hull of the ship. Inside, survivors, rescuers and the cabin, alike, were coated with oil. Three of the soldiers were so badly injured it didn't seem possible they would live until the ship reached port. The rest of the survivors were either toally or partially blinded from the oil and violently nauseated from the combined effects of oil and sea water. But Moss brought them in, just as the last shred of daylight was disappearing.

In the meantime destroyers had reached the *San Juan*. And all except seventy of the ship's total of 1,429 were eventually rescued. As for Moss, even the three wounded of his cargo recovered, and he and his crew received a Navy commendation.

In a war which has turned everything topsy-turvy, the Army has found itself flying over the sea as much as it does over land. But in other theaters of war, the close teamwork between Army and Navy is not possible. The Army has to send its landlubber planes out over great open expanses of water without the Navy standing by with seagoing rescue planes. That means that the Army Air Force has had to be particularly ingenious in devising ways of fishing airmen from the sea.

Most of the Army rescue planes are bombers. In England, for example, they fly an air-sea rescue patrol over the no-man's land of the North Sea and the Channel for every armada of U. S. planes out to bomb the Reich. Mostly they fly without fighter protection and there is nothing the Jerries like better than to catch one of the rescue bombers on such a patrol.

But the Army bombers, unlike the Navy's Dumbos, cannot go down on the water to pick up the men. The best they can do is drop survivors all the equipment necessary to keep them afloat until rescue comes in the form of a British crash boat or amphibious Walrus.

As a result, AAF emergency equipment is arresting in its resourcefulness. For special conditions, for instance, an Army rescue bomber will release a small seagoing craft completely equipped and entirely capable of making a 100-mile cruise.

This air-borne lifeboat is released by the bombardier of a specially fitted B-17 when he pulls the bomb salvo lever. As the boat leaves the plane, three parachutes automatically open and float it down to the water. Upon striking, two rocket-projected sidelines eject from each side of the 27-foot-long boat and act as sea anchors so that the craft can be reached by the men in the water.

The boat itself is unsinkable and uncapsizable. It is built of mahogany plywood, has a self-flushing deck and when the survivors climb aboard they find at hand an instruction manual of its operation and a map of the area drawn up by the plane crew which shows the position of the crew adrift and the best course to navigate.

Even a partial list of the equipment carried by this amazing lifeboat would make an average small-boat enthusiast green with envy. In addition to sails and instructions for sailing, there are two small five-horsepower motors, oars, tiller and rudder—in fact, everything necessary to proceed in the craft by wind, motor or elbow grease. Emergency equipment for its crew of survivors includes several types of signals, a waterproof flashlight, signalling mirror and salt water still. A change of clothing for several men, complete to long underwear, is stored in the boat along with four woolen blankets. Medical supplies include a complete first-aid kit, blood plasma, sunburn salve and soap which lathers in salt water. Even the gadgets of civilization have not been forgotten, and the ship's stores include can-openers, a clock, pencils, waterproof matches, knives with floating handles, police whistles and an air mattress.

This wonderful craft, which would delight any Captain Bligh, is dropped, however, only under very trying conditions. Usually both Army and Navy bombardiers, when they spot the green stain of fluorescein, or the red dye from Mae West canisters, press their bomb release, which drops a five-part emergency assembly. In Army argot this is known as the Lindholme gear; the Navy calls it AR-10. But essentially both are similar in nearly every respect. The Army has found its Lindholme gear ideal for airmen down in the North Sea, and the Channel, and the Bay of Biscay, while the Navy finds it more and more expedient to use the AR-10 for carrier-based planes out of reach of the Dumbos and down in the enemy's inner defenses.

Like Commandos, American rescue systems have been an outgrowth of British emergency measures. Early in the war both the British and the Germans developed means of picking up survivors or equipping them to survive until land was reached or rescue came. But after the Battle of Britain, the German efforts in this line fizzled out. Captured German rafts were found to be very much the same as American rubber boats, but the paucity of equipment on them, even considering the fact that German sea and land planes seldom ventured far from land, is amazing. A few canteens of water, rations and oars were about the sum total of their supplies. The British, on the other hand, with their remarkable maritime history, constantly increased both the scope and the ingenuity of their rescue system. As a result, the AAF working with the British found very little to contribute to it and the American air-sea rescue organization which operated in those joint theaters grew to be mostly an adjunct to the British system. American officers attended British rescue training schools and participated in missions flown from Coastal Command stations.

With thousands of planes shuttling back and forth from England to the Continent on a 24-hour day-in-day-out blasting of Hitler's Reich, the air-sea rescue patrols covering their water course were kept constantly on the alert. On a rescue bomber, the co-pilot kept in constant radio contact with a ground station. The ground station picked up all distress calls from the homeward winging armada, took a fix on the position of the ailing eagle and relayed it in code along with instructions to the rescue bomber. From there on it was the bomber's job to get to the spot on the double—some B-17's have been known to float for three minutes, but as a rule thirty seconds is all that is required for one to go under.

The scene of a crash landing at sea is usually marked by an oil smudge, flotsam or water-marking chemical. The rescue bomber makes two runs over the area. The first is a dry run, and the rescue officer, taking the place of the bombardier, drops a smoke flare as a marker and a wind indicator. On the second run the emergency bombardier, when he has lined up the spot in the cross hairs of the bombsight, pushes the bomb release button, under the belly of the plane, bomb bay doors open wide and the five barrels of the Lindholme gear drop out.

The first unit is a life raft which automatically inflates as it hits the water. The other four barrels spread out behind it in a long, easily accessible line held together by floating rope. The second barrel is a floating radio, while the other two contain warm clothing, food, water, ever-hot bags, leak stoppers, flares and weatherproof flashlights. Not the least of this equipment are the ever-hot bags. Survivors were picked up so weakened and numb with cold after drifting for days in the North Sea that they were unable to respond to the hail of rescuers.

The Navy's AR-10, which is dropped to men down in enemy waters, gives them a chance to get away. Like the

Army's Lindholme, it is a five-unit assembly. From the first kit, as if by magic, a large boat-shaped raft emerges. But this raft is no ordinary rubber boat. It has been designed so that it can be operated in rough water. When the fliers climb aboard it they find that it not only has been equipped with mast and sails, but that the other kits in the assembly contain an outboard motor and fuel. Stored inside the raft itself is enough food and water to keep ten men going for a week, as well as the usual complement of medical kits, pyrotechnic and mirror signals, blankets and all the other things that make up Navy emergency equipment.

In spite of Dumbos, crash boats, Lindholme gear and AR-10 assemblies, there are a vast number of fliers who come down at sea and must rely solely on the emergency equipment of their planes. Both branches of our armed forces have consequently embarked on a tremendous program of survival education for fliers. In the Army it starts with training for ditching a land plane while at sea; while the Navy trains its pilots how to get out of the cockpits of sinking planes. For this purpose, Navy plane crews, before they are ever out of training, are only too well acquainted with the "Dilbert Dunker." This devilish device is an actual plane cockpit rigged so that it may be dropped into the water, just exactly as would happen in a crash landing. The tyro straps himself in the Dunker by means of a safety belt; the device is hauled up into the air, then let fall into the water. Thirty seconds is allotted for the student to get out. If he doesn't come up for air at the end of that time, a diver goes down and gets him. Needless to say, after a few immersions in the "Dilbert Dunkers," Navy men soon learn the best and quickest ways of getting out of a submerged cockpit.

The Army's course in ditching a plane at sea is regarded by most AAF crews as the most boring procedure yet devised by superior officers—that is, it is until the moment comes when the crew of a B-17, a B-24, 25 or 26, or an A-20 have to land their big ships on the wrinkled surface of the sea. Usually at that time they see the usefulness of all the long and tedious drills, the dull training films, the tiresome checking of CO_2 cartridges, ration kits, canteens, signalling equipment and hatches. And the ratio of survivors of crash landings at sea is generally in direct proportion to the thoroughness with which crews have absorbed this training.

Ditching drills started with the Allied bombings of Germany and, as usual, originated with the British. They made a study of various forced landings and came up with certain procedures to be followed by British planes. When the American 8th Air Force arrived, the program was intensified and methods were devised for ditching the Army's four types of bombers and the A-20. Even as early as the spring of 1943, this training was paying off: sixty per cent of the plane crews downed in crash landings were living to add details to the program.

Sometimes a ship has to be ditched in the face of overwhelming odds. That's when the boring "dry runs" of training come in handiest. A B-17 returning from a raid over Wilhelmshaven, Germany, had to drop out of formation when two of its engines were shot out and a third began acting up. Limping along on its one good engine, the B-17 was suddenly pounced on by a pack of Focke-Wulfs. The saliva almost dripped off the wolf pack's cowlings: here was their favorite quarry—a crippled Allied bomber. They swooped down all set for the kill, but the pilot of the B-17 managed to keep up evasive action while his gunners gave the Jerries everything they had. And that is not exaggeration: every gun on the B-17 but the turret gun spent its last ounce of ammunition on the FW's. In return, the American plane took a blistering hail of fire which started fires in the almost severed tail and in the No. 2 engine. Co-pilot and waist gunner, respectively, succeeded in smothering both.

Only two enemy fighters were left to harry the badly limping bomber, when a companion B-17 came to the rescue. The rescue plane made short work of one of the German planes, but the co-pilot, who had taken over the turret gun, spent the last round of ammunition in shooting down the remaining Jerry.

At 7,000 feet, the pilot of the B-17 knew that he'd never get the plane back to base. "Prepare to ditch!" was the order, and each man responded as he took up his emergency position: "Co-pilot ditching"; "navigator ditching"; "waist gunner ditching"; and so on down the line. Mae Wests were checked; heavy flying boots slipped off, but the rest of their warm clothing was left on: the English Channel has never been known for its balmy weather. Before the bombardier took off his right boot, he raised his foot and smashed the bombsight. The B-17 had no bombs left to be jettisoned, but the crew busied itself tossing out guns, and everything else that might prove a lethal battering ram upon impact. The bombardier checked over the bomb bay doors: they were snugly closed so that no sudden inrush of water would occur upon landing. Some crew members sealed up the lower hatches as the last of the plane's dumpable equipment was jettisoned, while others unlatched the upper hatches so that they could be pushed open for quick egress on landing.

Only the radio operator and the navigator stayed quietly at their tasks; the radio operator busily sending out SOS's and call sign, and relaying the plane's position furnished him by the navigator.

Meanwhile, over the intercommunication system the B-17's pilot's voice was giving a running account of what was going on with repeated observations on the plane's altitude. Suddenly he broke his droning commentary: "Prepare to ditch!" came the order.

The navigator snatched up his charts, maps and celestial equipment, seized the emergency radio and signal set and hurried into the radio room. After him came the bombardier. He closed the forward door tightly as he entered. In quick succession the radio compartment filled up: flight engineer; right waist gunner and left waist gunner each one carrying equipment for dinghy use. The tail gunner came in last with an extra ration pack.

Up in the cockpit the pilot opened the window at his side. The co-pilot reached over and adjusted his skipper's shoulder harness so that physiognomy and instrument panel wouldn't become one on landing. Then he opened his own side window for quick escape, pushed his seat well back and tightened his own harness.

The intercom system crackled: "Radio operator, take your ditching post." The radio man plugged in the key that would keep the set flashing out signals until it went under water. Then he got down on the floor with the rest of the crew. Someone handed him a seat cushion. He buried his head in it to take up the shock of impact.

The B-17 skimmed across the surface of the water; landing gear pulled up; nose up; the tail just barely dragging across the top of the swells. Five seconds before plane and sea met, the pilot spoke his last order over the intercom: "Here it comes! Brace for ditching!" The radio operator raised his head from the seat pad: "Brace for ditching!" he repeated to the crew. Then he tore his earphones off.

The tail of the plane hit the water with a mild shudder. Then a teeth-jarring jolt struck the plane as the nose ploughed into the waves. The speed of the plane carried it a little way through the water, then the sea caught it and began rocking it gently. The crew came out from the floating plane like disturbed ants from an anthill. The ball turret gunner had pulled both dinghy releases before he left the cabin. They were already inflating on the wing as he came out.

It was perfect ditching. The pilot had brought the big B-17 down at just the right right-angle to make perfect contact with the top of the swell. The plane stayed on top of the water three minutes. And thirty hours after they had taken to the rubber boats, the entire crew of the plane was picked up in good shape.

13. How to Survive

TWENTY MILES out from Tarpon Springs, Florida, two orange life rafts rose and fell on the long swell of the Gulf of Mexico. In the smaller raft five men huddled under a tarpaulin out of the midsummer Florida sun; in the larger raft there were three men. Insignia on the uniforms showed that the men were Army air personnel, both officers and enlisted men. They were gaunt, unshaved, their lips cracked, badly sunburned; their flying suits were stiff with salt and rain-stained. They had spent six days and nights tossing around in their rubber boats.

Suddenly the noise of a plane was heard. A patrol plane winged across the sky, spotted the bobbing rafts, turned in a wide sweeping arc and began to descend. As it neared the water, an Army crash boat sped up and its crew waved off the plane.

One of the men in the rafts smiled through cracked lips at the Army Air Force medical officers in the crash boat. "Put this in your notebook, Doc," he said. "Even phony survivors are glad to see something besides themselves."

The AAF men on these rafts were guinea pigs of a new species. They were in training to be survivors, only an infinitesimal part of the gigantic educational program undertaken by the War and Navy Departments in that year of 1943. The goal of this program was the development of efficient and scientific salvage of human life, and it started in 1942 when, in a war which has left untouched virtually no spot on the globe, American seamen and fliers found themselves cast adrift on limitless seas, marooned on icecaps, coral atolls, in deserts and jungles.

The first part of the program was essentially a laboratory education for the Government: it had to find out what to tell its soldiers and sailors to do under emergency conditions; what procedure to take until rescue; how to exist under every sort of fantastic condition when no immediate rescue was in sight. The War and Navy Departments combed the personal experiences of pre-war scientists and explorers and the first few survivors of this war. But a thousand unanswered questions still remained.

Behind the Government's frantic efforts to develop a rescue and survival technique lay the experiences of men like Lieutenant Lawrence R. McKulla. During an air battle off the Solomon Islands, McKulla's plane was so badly shot up that he had to bail out over the sea. While he was in the water he was strafed by Zeros, but he escaped injury by hiding under his parachute. McKulla had come down near a tiny island, and when danger from the Jap planes was past, he started to swim for it. In his battle to traverse the mile and a half of water between him and the island, he was forced to let go his jungle pack and fishing tackle. After four hours he fought through the strong currents swirling around the island. He dragged himself up on the beach without a single piece of equipment, weapon or tool, and with nothing but the clothes on his back, his shoes, which he had to discard immediately because they were so badly shrunken after four hours' immersion, and his Mae West. The first thing he did was to fall asleep for four hours. The second was, on awakening, to look over the resources of the tiny atoll upon which he found himself. There weren't many: or to be exact, there were two—both of them coconut trees whose aggregate total of fruit came to exactly thirty-two.

With nothing but a diet of coconuts staring him in the face for days to come, McKulla decided on the third day to travel over to a larger island next to the one he was on. But without tools of any kind all attempts to make a raft failed and he resigned himself to the small islet and the coconuts—which incidentally provided drink as well as food, since he had not discovered any source of potable water. Most of his clothes he had been forced to discard: his jacket soaked in oil became as uncomfortable as sandpaper from the sand which clung to it. On the sixth day, a reconnaissance plane of the New Zealand Air Force spotted McKulla on his lonely island. They dropped him a container of water and some K rations. But the container hit a coral reef and broke and the rations sank in the surf before he could reach them. The next day the same plane returned. Their aim had improved and this time McKulla picked up food, a container of water, cigarettes, signal instructions, a Chicago newspaper, and a note. The note carried the cheerful news that a PBY would be around that afternoon to pick him up.

But the PBY never appeared. By the tenth day, McKulla was frantic with the thought that he had probably slept through the moment when rescue had arrived. Late that afternoon, however, his old friend in the New Zealand

Air Force showed up again and dropped more food and water, clothing, a compass which broke upon impact, a life raft and another note. This note instructed him to make his way to the south corner of the island and await a submarine which would be in that night to pick him up.

He was doomed to disappointment again. The sub never showed up, though the New Zealand plane came by religiously for daily visits and occasionally dropped food. On the sixteenth day it soared over and dropped its final warning: "It is intended that submarine pick you up tonight. Please try to stay awake and have rubber boat ready."

A few minutes after eight o'clock that night the unpunctual submarine showed up and McKulla was taken off the island. McKulla was lucky. His island lay on the course of frequent Allied plane operations. Otherwise the small island and its limited supply of coconuts would have undoubtedly proved a more horrible death-trap than the Japanese bullets.

Guadalcanal gave impetus to the survival educational program. Many Marine and Navy pilots who had been given up as missing or dead, after being forced down at sea or on isolated islands, later turned up. Some came back in a few days; others fought sea and jungle for as long as eight months before they got back to the haunts of white men. Men like Marine Pilot Lieutenant D. M. Leslie brought themselves back alive. Most of the time they did it without the benefit of what was then considered emergency equipment for Navy men: pistol, knife and first aid kit. A part of Lieutenant Leslie's own account reads:

"Upon struggling to get out of my parachute in the water I lost my web belt with my pistol, knife, canteens, and first aid packet, and also had to take my shoes off to enable me to stay afloat, so the first day I spent on shore found my feet cut and blistered and very tender. Lacking shoes, I made a pair out of my life jacket. On the fifth day after landing I found good drinking water but was forced to vacate when the Japs made a landing close by. During the first five days I drank water from old coconut halves and what little I could find in old stream beds. The fourth day I found an old door from a plantation house and with a life preserver made a raft, but was unable to launch it that night because of a storm or the next night because of a Jap landing party. While waiting for nightfall these days, I made several attempts to skirt the Jap positions but was unsuccessful. My food during this time consisted of coconuts, lemons (I had carried a dozen with me), and snails.

"During the ensuing two weeks I made repeated attempts to skirt the Japanese positions without success and was becoming weak from my diet of coconuts. My feet were in very bad shape, being cut, blistered and festered. Later, I found some Jap shoes but was unable to wear them because of the pressure they placed on the sores. My life preserver shoes wore out so I made some more out of discarded rags I found. Even though I slept on the ground and in rain several nights, I at no time during this period felt that I was physically sick, even though I realized that I was weak.

"I decided to try to get to the natives. But, after walking one day, I sighted what I thought to be one of our destroyers coming down the coast. Making a raft out of logs, I swam toward the ship but had to return to shore after finding that it belonged to the enemy.

"Using the same raft I swam down the coast until I was forced to return to shore by the cold. I then returned to the position from which I had sighted the destroyer, as I had found good drinking water there, and filled my water bottle. I found an old native canoe, which I fixed, and decided to paddle around the Jap positions. For the next three nights I paddled about three hours each night, or until I became exhausted. By doing this I skirted the Japs. On the third day and from then on until I reached the natives, I found food to be plentiful, having bananas, eggs, papaya and coconuts. After three more nights' paddling I reached the natives. This was twenty-five days after I was shot down.

"Upon arriving on shore I collapsed from exhaustion and the natives all ran from me, but after I shouted at them in English they returned and were very friendly. My feet at this time were in very bad shape, so they carried me to their camp, where I was fed very well with baked bananas, papaya and fish.

"During my entire stay in the jungle I at no time felt sick or feverish, even though the flies, mosquitoes and ants were very bad. The flies and ants bothered me the most as they were very annoying on my feet. My reaction to the fear of the Japs changed. At first, when I was in the water trying to keep out of range of the patrols on the beach, I had a much greater fear of them than I had after the two weeks I spent dodging them in the jungle. I had several face to face encounters with them but felt no great fear. At only one time, after I had been on shore about two weeks, did I feel that I was going to starve, or catch malaria and die before I got out. At this period I was badly in need of food. After finding the canoe and getting around the Jap positions and finding plenty of food my spirits rose. The reason that I was unable to secure more food while I was among the Japs was because of the fact that they had eaten all the fruit and game as they moved, leaving very little behind that could be eaten."

Marines like Lieutenant Leslie and Lieutenant T. H. Mann, Jr., were in those early days of 1942 disproving the Axis assumption that Americans were soft. But Mann's experiences, so different from his comrade's-in-arms, not only show how valuable, even in this first year of war, survival instruction was, but how different the chance of survival becomes when a man is able to hang on to the mechanical and tabular aids that the Army and Navy have provided. Mann's actual report of his adventures reads as follows:

"In the water landing, my face struck the gun sight on impact, knocking out two lower front teeth. I must have been knocked unconscious because the first thing I remembered was that the cockpit was full of water. When I got out and came to the surface my plane had completely disappeared. I found the Jap bomber making a strafing pass on me. I dove and swam under water away from the oil slick. Coming up the second time, I found the enemy plane turning to make another strafing attack. I dove under water again and upon coming up found the enemy plane proceeding to base. I started swimming toward one of the islands which was from ten to fifteen miles distant. After swimming some distance and looking back I found my rubber boat. I spent fifteen or twenty minutes trying to get into the boat from side and front. After taking off all loose gear and shoes, I got in from the back.

"Had quite a bit of shock due to the teeth being knocked out and the shrapnel wounds. After treating the wounds as best I could with my own first aid kits, using sulfanilamide, sulfathiazole powder and taking aspirin, quinine and salt tablets according to instruction, I spent approximately four hours rowing to one of the small islands.

"Arriving 100 yards off shore I found two native canoes behind me coming from an adjoining island. They took me to the shore where they gave me food, hot water to wash wounds, and rest. After resting they took me to their native village on another island about fifteen miles away. Upon arriving at the village they wrapped me in blankets (Marine Corps issue), and fed me hot tea, again dressing my wounds and giving me more food. My wounds were first scrubbed with soap and water; sulfanilamide powder was then applied and I was bandaged. These were from my first aid kit.

"This village numbered about 100 men, women and children. Three men could read, write and speak English. About an hour after arriving at the village I began to get over the shock from which I was suffering and the rest of the afternoon was spent in telling the villagers about the war and stories about America. The natives seemed very interested in when the war would be over in their islands, asking it if would be finished by Christmas. They informed me upon arriving that I would be returned the following day. The natives gave me a bed, blankets and mosquito netting (Marine Corps issue). My food for that night consisted of sweet potatoes, a native root similar to potatoes, ripe pineapple, a can of pears, papaya and more hot tea with sugar.

"The next morning I awoke feeling much better. They had hot water, soap, a Prophylactic toothbrush and Ipana toothpaste. For breakfast I received more pineapple, papaya, fried eggs, and French fried potatoes, hot tea and sugar. My shrapnel wounds were giving me no pain or irritation although I had a solid dull ache in my lower jaw where the teeth were knocked out. I took some more of the medicine from my kit, consisting of aspirin, quinine and salt tablets. I did not dress my wounds as I was out of sulfanilamide powder. At approximately seven a.m. they were ready to take me back. This trip of about forty-five miles was made in an eighteen-man war canoe. All during the trip the natives rowed constantly, pausing occasionally for food. We arrived at about five p.m. The natives were given large amounts of issue foods to take with them to their village. This consisted of tins of sugar, salt, coffee, tea and cartons of meats and other canned rations. The natives gave me large amounts of taro root (potatoes), sweet potatoes, and several papayas and pineapples to take with me. I gave the natives my hunting knife, compass, clothes, helmet and goggles upon their request."

Survival on the open ocean still presents the toughest problem. A Chinaman holds the known record for sea survival. For one hundred and thirty-three days he drifted across the Atlantic, squeezing drinking water from a rain-soaked rag and eating raw fish which he caught with his bare hands. When his battered raft grounded ashore he was able to get up and walk to land.

But on virtually every island of the Pacific, water, without which a man can live for at the most ten days and with which, even without food, he can stretch life out to approximately twenty, can be found. McKulla, in all probability, might have been able to find water on his atoll—all that was necessary was that he dig at high water mark on the beach until he hit water. If he had stopped at that point, the water welling up in the hole would in all probability have been brackish, but potable.

In the Arctic, however, there is no water problem. Ice and snow either melted in the mouth or over a fire provide good drinking water; in the summer, the abundance of lakes, streams and ponds provide an abundance of liquid refreshment. Even the dark, brownish water on tundras is drinkable. On the Arctic seas, water from icebergs and old sea ice, distinguished from new sea ice by its bluish color, splintering qualities and worn-down rounded corners is free from salt. But the hard, milky looking new ice is to be avoided because of its saltiness.

Early in 1943 the crew of a PBY had nothing but the equipment of their crashed plane with which to fight for their lives on Greenland's icecap. Survival in the Arctic, in spite of its abundant supply of drinking water, is at best a tenuous proposition. Its chief dangers are freezing, snow-blindness and carbon monoxide poisoning. And rescue is difficult because of the danger of crevasses. The seven men on board the Catalina brought to ten the number of men downed on Greenland's howling desolated waste at that time. Three Army men, remnants of the crew of a smashed B-17, one of whom had self-amputated his gangrenous frost-bitten feet, had been waiting rescue near Angmagssalik for weeks when the PBY, flying through snow and ice that blotted out all visibility, crashed into the side of an ice hill four hundred miles below the Arctic Circle.

The spot where the big flying boat made its unfortunate landing was completely surrounded by crevasses. In the six days before the rescue party arrived across the barrier from the plane, the seven men marooned on the ice had received supplies of food, clothing and a radio from Army planes which did much to improve living in the cramped quarters of the plane. In the tunnel hatch they had set up a head (privy) which outdid a Chic Sales creation only by its Arctic frigidity. This, and the tremulous life of their gasoline engine which charged the radio batteries, was their only connection with civilization. For the remaining ten days—making sixteen in all—they had to chop their hamburgers with axes while waiting for the arrival of five dog teams to traverse the crevasses and take them off the ice cap. And in addition to the joyous prospect of a delicious meal awaiting them, the Catalina's crew heard the good news that the three men of the B-17 had also been picked up.

The eight men adrift in the Gulf were a part of the comprehensive test which answered the questions of survival under all sorts of conditions. Their ordeal alone was to provide the answers for eight definite objectives:

1. To learn whether it is best to drink large quantities of water before being cast adrift.

2. To determine the advantages or disadvantages of keeping the clothing saturated with sea water in an attempt to conserve body fluids.

3. To find the relationship between such factors as exercise and exposure to the sun and the rate at which the body dries out.

4. To compare the advantages of drinking large amounts of water after prolonged dehydration with hoarding water collected and drinking small amounts of it at more frequent intervals.

5. To test the effectiveness of various sunburn lotions and creams.

6. To determine the desirability of including certain items of diet now provided as emergency rations.

7. To determine the practicability of all equipment in the life rafts.

8. To provide a source of information based on practical experience for teaching purposes.

Originally nine men had slid overboard from the crash boat, swam to the rafts in flying suits, socks, shoes and clutching fatigue caps, so that their arrival in the rubber boats would simulate all details of an actual crash landing at sea. But during the first sleepless night of rain and wind and ceaseless pitching, one man became so violently seasick that he had to be taken off the next morning. His removal revealed a hitherto unknown fact about the effects of raft *mal de mer*: that it can be fatal. This man, after only twelve hours, had lost eight and a half pounds; was in such severe shock that neither his pulse nor blood pressure were obtainable at times; was, in addition, completely disorientated and confused. Except for this one man, all the others remained constantly on the rafts except for short periods when the crash boat drew up and they were taken aboard for daily check-up of both physical condition of the men and their equipment.

The men stood the test far better than the equipment provided in that early stage of the war. After the first stormy night the contents of the kits fastened to the floor of the rafts were found to be almost completely ruined because of lack of watertight packing; signal flares were soggy and could not be used; the first-aid kit was soaked with sea water; the Very pistol and 45-calibre automatic were rusted tight and the rubber patching kit was so useless from one night's salt water soaking that it couldn't have been used to patch a pinhole in the raft.

Physical checks of the men, with one raftload acting as a control group, showed the advantages of eating as much food as possible, as well as drinking large quantities of water before being cast adrift. They also brought out the fact that saturating the clothing by taking it off, dipping it into the sea and then wringing it out before putting it on again went a long way toward conserving body fluids, and that exercise to the extent possible in the cramped confines of a raft helped a great deal in overcoming immersion foot. While it was also discovered that in the absence of sufficient quantities of water, it was better to avoid eating meat rations and stick to the hard candy, fruit bars and biscuits of the food packs.

Other tests meantime had been and still are going on by the Tactical Center of the AAF at Hypoluxo Island, not very far away from that ultra in rugged living afforded at West Palm Beach, Florida. Here airmen learn to live, and the Army learns how they do it, on the nearest approach to a Pacific island which the North American continent has to offer. As a matter of fact, Hypoluxo gives a combination of what one can expect to encounter on any or all of the South Sea islands. Animal and plant life is tropical in nature; thick mangrove swamps clot its coast and typical jungle terrain is found inland only a little way. Airmen are set ashore with nothing more than matches and machetes to live for days on the island. When they are taken off they are wiser by a good many things. They have discovered the potentialities of turtles both as food and cookpot; turned upside down and a fire built under him, the turtle not only makes good eating but his own shell serves as a cooking utensil. A prized Hypoluxo dessert, "coco royado," owes its origin to AAF ingenuity and consists of pouring the boiled sweet sap of flower shoots over grated coconut meat. And, once prejudices have been removed, the airmen are quite prone to discuss the gastronomic delights of lizards, snakes, insects and hearts of cabbage palms.

What to do in mountainous country: how to get stranded fliers out and how to live if you are a stranded flier is the essence of the Search and Rescue tests being carried out in the Idaho mountains near Gowen Field. Here the

Army lays stress on the proper way of bailing out over heavily timbered country—mighty handy information to have both for fliers who might have to parachute over this type of terrain and for medical men and rescuers going to their aid. Experience has shown that many airmen have parachuted over forests, only to have their chutes catch in high timber and be strangled to death in their shrouds or raked to pieces by tree limbs.

Special equipment for this type of parachuting has accordingly been developed at Gowen Field, and at a similar project of the ATC in a northeastern state near the Canadian border. This equipment consists of reserve chutes worn in front, in case the main chute fails to operate; drift chutes which fall at the same rate as a parachutist and football type helmets and steel masks similar to those used by baseball catchers.

The job of getting downed and wounded men out of rugged country like this is an especially strenuous operation. As many as forty rescuers have had to be sent in order to bring out the ten-man crew of a wrecked bomber. Such rescue units have to be trained for just this type of work. They have to be experienced skiiers: know how to cut trails and carry litter cases over rough country. Sometimes equipment such as caterpillar-type snowmobiles can be used. But in most cases both rescuers and rescued must depend on "shank's mare"—a slow process at best, for speed in rough up-and-down-hill territory seldom exceeds a mile an hour tortoise pace.

Tests and training simulate actual crash landings as far as possible. A group of Army men will be sent out into the wilds of the Idaho foothills to enact the role of forced down fliers. Radio reports are then sent out purporting to be from the forced down plane. From there on it is up to the rescue group to locate the stranded party by means of the yellow marker cloth spread out by the ground unit. One of the rescue crew then parachutes down to the stranded men, after first making sure of landing in the selected spot by tossing out drift chutes. Once he is down with the ground party, communications with the plane can be maintained through his portable walkie-talkie and his reports on the condition of the downed men decide whether a parachuting Army doctor is needed. If such is the case, in addition to dropping containers of food and supplies, the plane will also drop an 85-pound medical kit for the doctor's use.

From that point actual rescue proceeds. If the terrain permits, a plane specially fitted with stretchers can be landed; if not, then the men must be brought out by skiers and sleds drawn either by men or dogs.

The work being carried on along the Canadian border by the Air Transport Command is more Arctic in nature. The route of ATC fliers who made the northern run to England covered frozen lands far north of the United States. These men were, as a result, carefully coached in the art of keeping alive in the Arctic till rescued. And sometimes rescue was a long time coming. No so long ago, Coast Guardsmen spent an entire month searching for six men whose plane had made an unfortunate acquaintance with an Alaskan mountain.

Rescue work in the Arctic sometimes makes use of pack dogs who carry emergency aid to downed fliers. Sometimes, too, the rescuers must take the part of pack animals and drag sleds on snowshoes; while at other times the rescue party must use its wits and improvise ingenious hoists and trolleys for lowering stretcher cases from cliffs.

What the Armed Forces have learned about the art of living in practically every corner of the world has been translated into printed matter—making, incidentally, some of the most fascinating reading material for armchair travelers as well as service personnel that the war has yet produced.

The Army Air Force's authoritative and interesting booket, "Survival," for instance, is intriguing both in format and contents. A five-ounce pocket size volume, printed on waterproofed paper and treated with an insect-repellent chemical, it sums up the very latest in pioneer lore. Jungle instructions are especially interesting and cover every facet of existence in the tropics.

Unless you are forced down in enemy territory, it advises, stay with your plane. The intact outline of a plane is much easier for searching planes to spot than you will be. Then, too, both the emergency and standard equipment of the average combat plane will go a long way toward making a stay in the jungle more comfortable.

For one thing, a plane makes excellent quarters. If it is a multi-place plane, doors and cockpit openings can be screened with parachutes or mosquito netting. And if it hasn't been too badly smashed up by the landing there is always the chance that it can be flown out again. The procedure then is to secure it firmly by digging hub-deep holes for the landing wheels and staking down the wings and tail. If the radio is operating or can be made to operate the next move is to try to establish contact. Signals can be set up by lining upside down cowl panels on the wings where they will catch and reflect the sun. Or fires can be laid out all set for igniting when a rescue ship is sighted. These fires can be made even more noticeable by dousing them with small amounts of engine oil for smudge; with water for steam. Another effective signal can be made by stretching a parachute across a narrow stream by tying chute lines to trees on both banks. And if a man is downed in territory off the course of Allied operations, loud noises, preferably at dawn or dusk, when sound carries best, made by pounding on the airplane, shooting a pistol or blowing a whistle, will often attract unseen natives.

However, it warns, if you do come down in enemy territory, get away from the plane as quickly as possible. This is especially essential in Japanese-held territory where the natives are more than likely to be unfriendly and the little yellow men's patrols are on the alert. All classified papers should be burned and all secret instruments destroyed. Then, as a final gesture before departing, the plane itself should be set afire.

If, on the other hand, the situation demands bailing out, "Survival" has succinct advice:

"Tuck your maps and emergency rations inside your clothes.

(Incidentally, Canadian Air Force personnel wear at all times in the air a sort of romper suit fitted with pockets which contain a minimum of emergency equipment.)

"Make your way to the wrecked airplane if it is not too far away.

"Prepare some sort of signalling device for instant use.

"Wear or carry with you appropriate clothing.

"Wear shoes that you can walk home in."

Once a decision has been made to leave the plane and to travel through the jungle, start out by *not being afraid of it. . . . You will probably be safer from sudden death in the jungle than in most city streets!* Good food and water are fairly plentiful; poisonous snakes and ferocious wild animals are correspondingly scarce—and if they are around they will be just as anxious to avoid man as man is to avoid them. The worst enemies of the jungle are disease-carrying insects; poisonous plants and fish; these latter are dangerous only when they are eaten. To guard against mosquitoes, the night biters which usually transmit malaria, sleep under mosquito netting if you have it, or under a parachute. Be careful not to have the sleeping protection fall against the body as the insects will bite through it. During the day—and at night too—wear full clothing and tuck trousers into the tops of socks. If emergency equipment includes insect repellents, it should be rubbed frequently on the hands, face and all exposed skin areas. And atabrine should be taken every night as long as it lasts—even if bitten by a malarial mosquito, a whole month will elapse before the first onslaught of the disease.

Ticks and leeches are also numerous in the jungle. They are picked up from high grass and underbrush. Clothes should be taken off once a day and searched for them. And, at that time, it is a good idea to wash all wearing apparel, for dirty clothes not only rot but can also lead to skin diseases. Don't pull a tick off when he's biting, for the head often remains attached and will sometimes work its way under the skin and set up an infection. A better way is to touch him with a lighted cigarette or put a drop of iodine on him. The same methods work with leeches, and a pinch of salt is also efficacious.

Spiders, scorpions and centipedes are both numerous and large. (In our own Southwest, centipedes come a foot long!) They are also poisonous, but not fatal by any means. They are not apt to bite or sting, however, unless touched or otherwise provoked. They like secretive places, so look carefully in shoes, socks and clothing before putting them on and examine your bed before lying down. In spite of all these precautions, if a spider or scorpion should get on your skin, let it crawl off unassisted.

Wearing shoes not only protects the feet against ants, chiggers and other crawlers, but also prevents ringworm and other infections. In the case of ants, it is wise not to pick a camp or sleeping spot near an ant hill or trail. Shoes and sleeping off the ground also guard against danger of poison snake bites. Watching where you put your hands also helps. But, if in spite of mutual reticence, contact is made between a viper and you, the following first aid procedure applies:

"Don't give alcohol. Put tourinquet above (loosen every twenty minutes); make cross-cuts through bite; apply suction over bite—suck over a piece of rubber tissue if available or by mouth, but spit out the poison immediately. Keep up suction until swelling stops."

Crocodiles and alligators seen in larger streams seldom attack a man. They can be frightened away by making loud noises or thrashing the water. If engaged in hand-to-hand encounter with the brutes, a native trick is to gouge the animal's eyes.

There are two types of fish to be avoided in the tropics. The first are poisonous fish: their flesh when eaten will result in sickness. It is also wise never to eat the liver or roe of any fish, as these parts are often poisonous. Most poisonous fish do not have scales like goldfish and bass; they are usually covered with spiny scales, or tough spines, with bony plates or with soft bristles like hair. Most of them also have hard, shiny, turtle-like beaks. Their shapes are unorthodox, also, being as a general rule boxy and ugly. The commonest are *puffers, trunk fish, thorn* or *horn fish, file* and *trigger fish.*

The second class of fish to be avoided are ferocious and venomous fish. The lump fish, an ugly, vicious creature, hangs out around coral reefs where its coloring blends with its surroundings and makes it difficult to observe. Shoes should be worn at all times when wading in shallow water for shell fish or fishing as protection against its bite, which is as dangerous as snake bite and should be treated accordingly. Shoes also provide protection against infectious cuts from coral, fish spines, and the fine spines of sea urchins. Other nasty and antagonistic denizens of the surf are the *great white sharks, moray eels, giant barracuda* and *sting rays.*

Then there are the poisonous plants. Figs, breadfruit, mango, sapodilla, and papaya are the only ones having a milky sap which are safe to eat. All others should be avoided. Also taboo are the seeds of even edible fruits and plants, especially if they come in pods that look like beans. If no other food is available, however, break and cut them up; soak in water and then cook. Before eating, however, try the following edibility test:

"Eat a spoonful and wait eight hours; if there are no ill effects, such as vomiting or diarrhea, eat a handful and wait another eight hours. If there are still no ill effects you can eat reasonable quantities safely. When you find the same food somewhere else, you will know it is safe to eat."

Not to be eaten under any condition are the *beach apples* or *manchineel* of Central and South America. This small, tree-like plant grows in the sand along the seashore and bears tempting looking small green apples. Its fruit is deadly poison. In the Southwest Pacific and Asia the nuts of the Candlenut tree—similar to China's Tung tree—are edible though slightly laxative in nature when roasted and are best when half ripe. The dried or roasted nuts, strung on a stick, will also burn like a candle when lighted. Even the safe kinds of taro—those having arrow-shaped leaves—must be thoroughly cooked to remove poison. Be careful of plants that look like taro but have a milky sap. Yams common to Africa, Asia, Australia and the Pacific must also be cooked before being eaten. Some must be soaked for days before all poison is removed. The same procedure must be followed in order to eat the seeds of cycads, which are not palms but resemble them closely. While the palm fruits growing on climbing palms are perfectly safe, *the fruits of ordinary palms are to be avoided.* Three other poisonous plants to be avoided at all costs are: Sanbox, a tall tree whose trunk is covered with spines and bearing a small, pumpkin-like fruit; Cowitch, whose beanlike, hair-covered pods should not even be touched, as they set up an irritation; and Strychnos, a vine with small, bell-shaped fruit which contains the deadliest poison known.

So much for the things that must not be eaten. There is still plenty of edible food left in the jungle. A good rule to follow is that you can eat anything you see a monkey eat; and that you can find many kinds of edible plants growing along the margins of streams, swamps and open spots. Sometimes fruits or nuts will be found on the ground under trees. And in still, shallow ponds and lakes, the roots, seeds and tender stems of water lilies are nutritious raw or cooked. Palms, in all probably, will, however, provide the mainstay of your vegetable diet. In Central and South American any plant of the palm family is safe to eat; in Asia and the Southwest Pacific, don't eat palm fruits having a burning taste or any parts of feathered leafed palms; in Africa, avoid the fruit of wine palms.

In many parts of the tropics the natives usually have gardens at varying distances from their villages. Finding such a garden is usually a sign of nearby habitation. If you are reasonably sure you are in friendly territory and cannot locate the owners, a good plan is to leave a small token in payment of what may be taken. In hostile territory, or in the case of an obviously abandoned garden, you can expect to find (and take without payment) coconuts, bananas, mango, custard apples, papaya, guava, avocado, sugar cane, pineapple, and usually a staple crop of rice, corn, plantain (cooking bananas) or breadfruit, along with root plants such as peanuts, yams, sweet potatoes or cassava.

For meat-eaters, game is scarce in the jungle, and most of it takes to the trees. Sloths can be killed with a club; hunting at night with a light might turn up some others and traps and snares snag a few more. The larger animals are wary and don't present themselves for a shot very often. Frogs and toads, however, are edible. They should be skinned before being eaten, since some kinds have poison glands in the skin. Turtles make very good eating. Watch their beaks and claws. Big ones are found along beaches and can be rushed and flopped over on their backs. Soft-shelled turtle eggs are prized by some peoples. Locate them by following turtle tracks which look like miniature tank treads in the sand . . . where the tracks end, you'll find the eggs. Snakes also come under the head of a delicacy in some quarters. Watch that you're not bitten and, to remove poison, cut off the head before preparing. Lizards, likewise, can be eaten if you can catch them. A noose snare sometimes works, or fast action with a club. Birds and their eggs are all safe. Eggs are good even if there is a live embryo inside.

Insects, if you can overcome prejudices, are food for emergency use. Termites, for instance, will come out of the ground in large numbers after a rainfall and can be scooped up and eaten by the handful, either raw or cooked. First remove the wings, however. The same procedure can be followed in the case of grasshoppers and crickets, but legs as well as wings must be removed.

Beetle grubs, found in dead stumps and fallen trees, can be detected by their scratching sound. Use a jungle knife to cut open the wood and extract them. They can be dried in a can over a fire and eaten or combined in a stew of root plants.

If your route lies along a coast, the food situation is apt to be fairly safe, if monotonous. Shellfish can be picked up with just your bare hand or a knife. Outside of dead ones—generally detectable by a disagreeable odor or failure to move upon being touched—all can be eaten either raw or cooked. Snails and limpets are easiest to catch and most plentiful. Only the flat mealy foot of the Chiton is worth eating and some skill is required to sneak up and flip it off its rock. Sea mussels and clams can be dug from coastal flats or pried off rocks. They generally give themselves away when buried by spitting or bubbling. Don't bother with shellfish found in colonies where there are a great many dead ones. The purple or green pincushiony sea urchins can be broken open and the red or yellow eggs inside eaten, and starfish eggs are good too. Sea cucumbers can be prepared by discarding the insides, scraping the skin to remove the slime, parboiling and frying. Lobsters, crabs and shrimps can be caught in nets or with forked sticks. Both crabs and lobsters will hang on to a piece of bait tied to a length of line when it is drawn up slowly. When near the surface they can be snared in a net. Jellyfish and sea worms are taboo.

Along the banks of inland streams, snails, clams and crawfish can be found. Crawfish are almost as delectable as lobsters when cooked.

If you are in the jungle, water is plentiful. But all of it must be purified by one of the following methods:

1. By boiling for at least one minute.
2. By using the halazone tablets in first aid kit.
3. By adding two or three drops of iodine to a quart (canteenful) and letting it stand thirty minutes before drinking.

It is not necessary to purify fresh rainwater collected in clean containers.

Many jungle plants, too, are the source of refreshing liquids. Green unripe coconuts are best. Lengths of vine can be cut, sharpened at one end and allowed to drain into containers. Bamboo joints often secrete water. And collected rainwater can often be found at the base of plants; on leaves; in tree holes and in the crevices of rocks.

To travel in the jungle your best friend will be a machete or knife—the larger and sharper, the better. With such a weapon you will be able to slash your way, secure food, make a raft. Other handy equipment includes a compass to help hold your course, a first aid kit and stout shoes. Any other items such as matches or lighter, maps, signal mirror, sun glasses, watch, gun and ammunition, wire or shroud lines, extra socks and clothing, which can be packed in a twenty-five to thirty-pound pack will come in handy. A good pack can be made from parachute fabric or canvas, using parachute harness to strap it over the shoulders high enough so that it won't bang against hips or kidneys at every step.

Before starting out, your position should be fixed as closely as possible. Look around and note the prominent landmarks—mountains, coastlines and rivers—and mark them down on a map if you have one. Travel in dense jungle in the absence of trails is best in a prone position. Don't try to fight through the undergrowth . . . it is too exhausting. If a stream or river is nearby, follow along it; if not, go down hill—that usually leads to a watercourse. In mountainous jungle travel the tops of ridges though precipices sometimes make detours necessary. In elephant country, follow the elephant trails. They are wide; never lead over terrain apt to bog down or be dangerous to traverse. Other game trails, while narrower, also make good guides.

If you are with a party *stick together.* And if you do get lost: don't get panicky. Try to think back to where you went wrong, then retrace your steps till you recognize your surroundings. Then resume the original course. Holding course can be done by picking two visible objects —trees or other prominent objects—on the line you want to follow and heading in their general direction. As you near the first objective, line up another and proceed in this manner.

Avoid swamps and wet mud flats. Four American aviators, whose plane conked out over a South American jungle, picked what seemed a likely place for a landing only to discover they had come down in a jelly-like mess of mud five feet deep. One of the crew was injured and while waiting till he was able to travel they lived on top of their plane. They used their parachutes to collect rainwaiter while they were housekeeping on the mud. Then, when their companion was fit to go on, they made snowshoes out of odds and ends in the plane, which made it possible for them to skim across the sinkhole. For the next twenty days they beat their way through the jungle, coming out at last to a stream. On its banks they built a raft which eventually floated them downstream to habitation.

Don't force yourself on the march. On level ground the average rate of walking is about two and one half miles an hour. Rough country cuts this down appreciably. You'll need plenty of rest as well as food in order to come out. Travel through the early part of the day. By three or four o'clock start looking around for a good camp site; sign off by five—there won't be much light left anyhow. Gather plenty of firewood and light a fire every night. If you have no matches, the old Boy Scout trick of twirling a stick in a board will do the job. Even in rainy weather, dry tinder for this can be obtained from the heart of dead trees; in palm country the fuzz from the underside of palm leaves will act in the same capacity. In building a fire, arrange the wood in a radiating pattern, like the spokes of a wheel. And for double insurance against wild animals, an armful of bamboo thrown on the fire will go off like firecrackers all through the night.

Regardless of food and water and courses set and held, you won't be able to make any headway unless your health is good. Being careful to keep well in the jungle almost approaches the point of being neurotic. Little cuts and scratches which would ordinarily be ignored must be attended to promptly, for the danger of infection is always present in the tropics. Your feet are your first concern . . . they are all that you have to carry you home on. Examine them carefully at every stop; put adhesive over red spots and blisters; wear two pairs of socks if possible—the inside pair wrong side out. For dysentery—which you won't get if you purify all drinking water and eat only fresh-cooked, or fresh-opened food—stay as quiet as possible and on a liquid diet. Put two salt tablets in each quart of drinking water.

If you find a stream or river large enough to float a raft on, use it to hasten your progress. The rubber raft from the plane can be used if it has been possible to carry it along; if not, a homemade contrivance can be worked out. To build a raft, the first job is selecting the wood. In tall old jungles, most of the wood found will be too heavy to float. But sound, light, dry wood can be found in old clearings, along the banks and on sand and gravel bars in streams. Using poles ten to twelve feet long, skin them of their bark for increased buoyancy, and lash them together with vines or parachute shrouds. An improvised tarpaulin covered boat can be made by bending saplings into a framework.

For either raft or boat, don't forget a sun and rain shelter rigged from parachute cloth. And keep your ears open when aboard at all times for the sounds of falls and rapids. It's wiser not to try to shoot rapids. Getting the raft through them by floating it empty at the end of a long piece of rope or vine sometimes works. Otherwise portage around dangerous spots, or discard the old raft and build a new one below.

Navigate waterways only when it's light; stay near shore; and, if you are alone, don't go to sleep.

With the exception of New Guinea and parts of Assam, most Pacific natives will be friendly. *Always be friendly, firm, patient, and honest in return with them.* They are most apt to be found along coasts or streams and trails. When you find them avoid close contact with them; don't sleep in native huts. The least you can get if you do is body lice. Stay away from native women; they have body lice, and worse.

To get on a friendly basis with natives, try some simple trick you learned in childhood—make cat's cradles or spider webs with a piece of string or vine. Even if you've forgotten how it will serve. The natives like them and will probably attempt to show you. It breaks the ice. Or offer them tobacco, matches, jewelry or knick knacks of some kind. Don't act scared or display weapons. Don't make sudden movements.

If you have to live with natives for some time, remember your manners. Don't go into native homes unless invited. Don't go into taboo areas or kill taboo animals. Respect the local customs and manners; don't be condescending or bullying. Primitive peoples are fond of practical jokes; if one is played on you be a good sport about it. Avoid giving offense about such things as preparing your own food, boiling drinking water and having your own quarters by politely explaining—in sign language if no one understands English—that it is your custom. That they can understand, being superstitious by nature.

Few men have been able to cope so successfully with a savage people as did Lieutenant Wallace L. Dinn, who had to bail out over a Japanese-held island after a raid. He floated down into the midst of a tribe who were just licking their chops after having dined on two Japanese pilots. They weren't hungry exactly, but he looked good to them. Lieutenant Dinn did some fast thinking, and fast talking. In pidgin English he sold them quite a bill of goods; plenty big fella knives for a big fella canoe and escort to take him back to his naval base. It worked. And on the way home, the lieutenant and his party stopped off at an island, captured a Japanese flier and brought him back a prisoner of war.

If you come down in the desert, "Survival" says, the best advice is to stay with the airplane. In the desert, water will be your main problem and you'll last much longer by staying quietly in the shade by your plane than you will by trying to walk out. Leave the plane only if you are sure you can get to assistance *easily* and are certain you have enough water to see you through. The following table gives you some idea of what to expect:

Desert Water Data Table

This chart shows you approximately how many days you can survive and how far you can travel on various amounts of water.

Maximum Daytime Temperatures in Shade	*Entire Water Supply per Man*	*Approximate Survival Days Resting in Shade at All Times*	*Approximate Survival Days—When Traveling Only at Night and Resting in Shade by Day. Also Distance You Can Travel*	
Very Hot 100°F. & above	No water	2-5	1-3 days	20 miles
	1 quart	2-5½	2-3½ days	20 miles
	2 quarts	2-6	2-3½ days	25 miles
	4 quarts	2½-7	2½-4 days	30 miles
Moderately Hot 80°—100°F.	No water	5-9	3-7 days	20-40 miles
	1 quart	5½-10	3½-7½ days	20-45 miles
	2 quarts	6-11	3½-8 days	25-50 miles
	4 quarts	7-13	4-9 days	30-60 miles
Cool Under 80°F.	No water	9-10	7-8 days	40-60 miles
	1 quart	10-11	7½-8½ days	45-75 miles
	2 quarts	11-12	8-9 days	55-100 miles
	4 quarts	13-14½	9½-11 days	60-150 miles

The importance of water rationing is obvious. Don't gulp your water ration: drink only in small sips and hold it in your mouth for a few minutes. If water supply is very scant use it just to moisten your lips.

Look for water by watching the action of birds and what few animals you may see. In semi-arid countries, birds chirp around a spot where water is available, animal runways and trails may lead to water. In very dry desert, water holes are sometimes discerned by the flocks of birds soaring over them. The presence of plant life does not always mean surface water, though some desert plants store water. The wild pineapple, for instance, of tropical America and Africa collects rainwater at its base; the pulp of American cacti contains fluid. The same advice given for jungle plants having a milky sap holds good for the desert; however, in Australia, the roots of the gum tree often store water.

If dew falls at night it is sometimes possible to collect it by digging a hole, lining it with a fabric and weighting it down with stones. Along sandy beaches, digging a hole at high water mark and scooping out the first fill gives drinkable, though brackish water. In stony desert dig at the lowest point in the outside bend of dry stream beds. In dune country, dig at the lowest point between dunes until water is reached. Along mud flats in winter, water wrung out of the mud by being twisted in a cloth may be drunk if it is not too salty or soapy in taste. Any water found in water holes or at oases must be purified.

In order to make what water you may be able to get stick with you longer, observe these rules: stay in the shade at all times during the day. Find what natural shelter you can from the sun, such as caves, rocks, ledges or wall of a dry stream bed. In this latter case, watch out for sudden floods. Don't hole up in the plane during the day. The desert sun beating down on its metal sides will make a cook oven out of it that will completely dehydrate you. If you have no other shelter get under the plane wings.

A good shade leanto can be easily rigged up around the plane by fastening parachute fabric from the wing and staking it down on the desert floor. Leave two feet at least open at the bottom for air circulation and be sure the plane is well staked down itself so that it won't veer around in a storm. If the plane is a low-winged type, dig the sand out from under the wing . . . the farther down you go the cooler you will find it.

To make a shelter without a plane, scoop a hole out of the sand, weight a layer of parachute cloth over it with large rocks or stones, place other rocks on top and add another layer of cloth weighted down in like manner. A double layer shade such as this is more effective than a single layer shelter. Lacking all materials, dig a hole in the sand, crawl in it and cover yourself with sand.

If you are going to attempt to walk out of the desert travel only at night time or in the early morning before it heats up. Hole up during the middle of the day in any one of the manners outlined above. Wear clothing for protection against sunburn—one of your deadliest enemies in the deserts—sand, insects and *heat.* Keep the body and head covered during the daytime—you'll last longer on less water. Don't cut off the legs of your trousers and keep your shirt sleeves rolled down. If you have a hat wear a cloth or scarf neck covering under it; if you have no headgear, improvise one similar to that worn by Arabs. During dust storms cover your nose and mouth. During the day wear sun glasses at all times; if you have none take a piece of cloth, cut slits in it for eyes, tie it around your head. Take your shoes off often and shake the sand out of them. Make puttees by winding strips of cloth around the lower legs and overlapping shoe tops. They'll keep out sand and sand fleas.

Don't throw away any clothing. Desert nights can be very cold, especially in the wintertime. If you haven't any heavy equipment wrap yourself in your parachute at night.

Some of the hazards to health found in the jungle are also present in the desert. The danger of infection from even the smallest cuts and scratches is even greater, as our troops discovered in the deserts of North Africa. Scorpions and spiders also abound and shoes and clothes must be carefully inspected before donning. Mosquitoes in the neighborhood of villages and oases are malarial. Ticks, carriers of typhus and relapsing fever, are numerous in most areas. Desert heat can cause three kinds of collapse: *Heatstroke*—may come on suddenly; the face is red, skin is hot and dry; all sweating stops; there is severe headache; pulse is fast and strong; unconsciousness may result.

Treat victim by cooling him off. Loosen his clothing; lay him down flat *in the shade*. Cool by saturating clothes with water and by fanning. Don't give tea, coffee or whiskey. If water for cooling isn't available, scoop out trench in sand, place man in bottom and rig sun shade, leaving air space for ventilation.

Heat exhaustion—results from too much exposure to sun and too much sweating. Victim is first flushed, then pale, sweats heavily, has moist, cool skin, may become delirious or unconscious.

Treat by placing in shade, flat on back with head low. Give him salt dissolved in water—two tablets to a canteen. Since he is cold, keep him wrapped up and give warm drinks if possible.

Heat cramps—the first warning of heat exhaustion usually is cramps in legs or belly muscles. Treat by massaging sore muscles gently; keep man resting; give him salt dissolved in water.

Most desert inhabitants are found along the coasts or near water holes and oases. They are generally nomads. In Southern Arabia they are likely to be hostile—be on guard. In the African and Middle East deserts, the inhabitants are Mohammedans, proud and independent. They take their religion and customs seriously—don't forget the pocket guide injunction, to use only the right hand for eating. The left is taboo because it is associated with calls of nature.

Coming down in the Arctic isn't much fun but it's being done quite a lot in this war. Survival isn't a facile operation and the rescue job is tough. For an hour-by-hour account of how to keep alive in the far north, "Survival" has some interesting and pertinent information.

To make it easier for search planes to spot the missing party, the AAF booklet has this to say:

"Keep snow and frost off airplane surfaces to make a sharp contrast.

"Build three fires on prominent points. Use smoke fire by day; oil and pieces of rubber make a dense black smoke; at night, use a bright flame fire. Try to collect and keep enough fuel on hand to keep fires going day and night.

"Tramp out giant S.O.S. in snow; make letters at least 100 feet high; to make them stand out better line with dark boughs. Lay down large circles of spruce or evergreen boughs on snow.

"A parachute tepee stands out in the forest or on the tundra in summer, especially at night with a fire going inside.

"Use orange paint, if provided, to cover part of the airplane—paint in checkered pattern to cover largest possible area rather than a solid small spot.

"Spread wing covers with orange surface uppermost."

As has been said previously, there is no water problem in the Arctic. In the winter, ice and snow provide water; in the summer, lakes, streams, and ponds supply an abundance.

And, except on the frozen wastes and ice caps of the polar regions, food is easier come by than on the desert. Food, however, is far more important in the Arctic than it is in the warmer zones; a lot of it is necessary to keep the body warm. With the exception of black mussels, polar bear liver, red or yellow mushrooms, baneberry and water hemlock, no northern animal, sea food or plant is poisonous. Sea food is most plentiful. Fish can be found along practically all coasts and in lakes and rivers. When waterways are frozen over, fish can still be had by chopping a hole in the ice and fishing with lines or spears. Shellfish can be located along the shores. Gulls and sea birds often give away the presence of schools of fish by their activities over certain areas.

Birds themselves furnish good eating. Look for their nesting places on islands, cliffs, marshes and the reedy shores of lakes, where they are easily caught nesting or where you can gather eggs. An excellent weapon for bird hunting is an improvised slingshot. In the summer, ducks, geese and swans shed their flight feathers. They can be searched out in the grass and reeds around lakes and clubbed to death, as can ptarmigan or Arctic grouse.

Don't be discouraged if you don't see any animal life right away. Look around for tracks, feathers, hair from fur, excrement. When it is extremely cold, animal "smoke" can be seen. It is the warm air exuded from animals' bodies which turns into steam in the cold, just as warm breath does in cold weather. Don't concentrate so much on the larger game animals such as caribou, moose, bears and seals. Caribou live mostly on the tundra, though sometimes they are found in the forests. Moose live along waterways and thickets of broad-leaved trees. Bears live in all parts of the Arctic. These animals must be hunted with rifles and moose and bear are very dangerous when wounded. To bring down mountain sheep requires a crack rifleman and they should be approached from above.

Unless you have a boat, it is impossible to retrieve seals from the water. If you catch one at rest on sea ice—which you won't unless it happens to be summer—it is possible to sneak up on it behind an improvised shield of white cloth. Move forward only while the seal has its head down. Aim at the head.

Smaller game, rabbits, ground squirrels, marmots, tree squirrels, foxes, lemmings and porcupines are easier hunting on the whole. They can be snared or shot or attracted within slingshot range by imitating the sound of a crippled bird or mouse by kissing the back of the hand violently to produce a "squeaking" noise. Rabbits are found in forests and among rocks on the tundra. In winter they can be found most often along the banks of streams and their presence is indicated by the chewed bark of trees and shrubs. Sometimes they can be scared out of hiding by shooting off a gun. If you are hunting in pairs, it might be wise to copy the rabbit hunting tactics of our own western coyotes when you have scared up a rabbit: one coyote always takes a quiet stand at the point where the rabbit was originally flushed, while his companion with many yips and howls follows noisily in the startled rodent's wake. The coyotes deliberately take advantage of the rabbit's proclivity for running in ever narrowing circles back to its original starting point, where the silent partner in the deal takes over.

Ground squirrels and marmots are burrowing animals; the former are found in the tundra and the latter inhabit mountain meadows above timberline. Both animals will run directly past you if you get between them and their burrow. Torn up pine cones on the floor of the forest or snow indicate the presence of tree squirrels. Turn up rocks and turf in tundra areas to find lemmings, a sort of stub-tailed mouse. Porcupines stick strictly to forests. They are slow-moving and can be killed with a club.

Northern plants are relatively small and generally widely scattered. Don't be discouraged, however, by the apparent bareness of the north. Often food will be found in the form of berries lying under bushes, and many of the Arctic plants store starch in their root systems. In the forest, look for food plants along waterways; in the tundra, seek out damp and wet places. Watch the feeding habits of animals—particularly birds. They will often lead you to food.

Dig up roots rather than pull them out by hand; then they won't break off. Raid the burrows of meadow mice—they often have a cache of roots stored away. Most roots may be eaten raw, but their food value is increased by stewing.

The leaves of bistort, wild rhubarb, dandelion, marsh marigold and fireweed make good greens. The leaves of some northern plants may contain poison or be disagreeable in taste, so take the precaution of stewing before eating. All northern berries with the exception of the baneberry previously referred to are safe to eat. Look for them sharply on the tundra where berry bushes are often low-growing and not easily observed. The inner bark of the roots and stems of spruce, willow, and birch contains food also. Peel off the soft inner bark, cut into narrow strips and it is good fresh or cooked with meat. The strips can be kept indefinitely without losing their food value. Lichens, too, those coral-like or disk-shaped plants which have no flowers, leaves, stems or roots, while not having a great deal of food value, will sustain life. They make handy ration-stretchers mixed with other foods in soups or stews. All lichens must be cooked or soaked overnight before being eaten. They are best when soaked, dried until brittle, crushed into powder and then boiled for about an hour. Like lichens, sea weeds can be eaten but do not contain much in the way of food value. Eat only the broad floating ribbon forms, the branched forms attached to rocks between low and high tide levels, and the green crinkled sheet kind. Don't eat sea weeds which smell fishy or are wilted and slimy.

Don't travel in the Arctic in the winter unless all hope of rescue is gone. Stay with your plane winter or summer unless six days or more have passed and no rescue attempt is apparent. If you do set out, be prepared for a difficult and bitter siege, especially if it is wintertime. Make a pack from parachute fabric and straps and carry as much of the following as will go into a twenty-five or thirty-pound pack: Matches or lighter, compass, maps, first-aid kit, knife, water, food, signal mirror, sun glasses (or improvise as for desert, out of cloth or piece of wood with eye slits), watch, small bottle of gasoline, wire or chute lines, extra socks, with enough room and weight left over for sleeping bag, parka, mittens, snowshoes, or skis and mukluks. (In summer, don't forget mosquito netting, extra clothing, especially socks, and shoepacs.)

Snowshoes can be improvised from willow twigs, airplane inspection plates, metal panels, seat bottoms or metal tubing. Sleds can be made from cabin doors, cowlings or bomb-bay doors. Ropes can be made from 'chute lines: each line has about 450 pounds tensile strength.

The same general rules for travel as previously noted for jungle and desert hold good in the Arctic. Make camp early so that there is plenty of time to build a shelter and a fire with which to dry out shoes and clothes. The biggest meal of the day should be eaten at this time and should be hot. Start early in the morning as soon as it is light.

In winter, the main problem in the Arctic is protection against cold. You will need shelter against the cold, so if possible camp in timber where you can secure wood and boughs for lean-to and firewood. On the tundra, where fuel is scarce, look for white heather, willows along creeks or shrubs. Dig for roots if nothing else is available. On the coasts, look for driftwood.

Chunks of animal fat or congealed oil stuck on a stick or bone framework with a wick of greasy cloth underneath will burn. A simple heater for a small shelter can be made by burning a candle in a tin can. Don't camp directly at the base of slopes or cliffs or under hanging ridges where snow may avalanche down and bury you, or put out your fire. Be sure to provide ventilation: carbon monoxide is caused by any fire burning in an unventilated area. In forested areas a good shelter can be made by laying boughs shingle-fashion, starting from the bottom; if you have canvas, use it for the roof; close ends with fabric or boughs. Make a back wall for your fire (made in front of the shelter) by setting two or more logs on top of each other and held in place by stakes at both sides. In timberless country, make a simple snow cave or burrow by digging into the banks of snow and lining the hole with grass, brush or tarpaulin. If the snow isn't deep enough to support a roof, dig a trench in a drift and roof with snow blocks, tarpaulin or other material supported on short poles.

Don't sleep directly on the snow. Provide some sort of insulation between your sleeping bag and the snow. Stamp the snow down hard and lay boughs down shingle-fashion, use seat cushions, tarpaulins, or even an inflated and inverted life raft.

Keep your sleeping bag clean, dry and fluffed up for maximum warmth. Dry it by turning inside out, beat out the frost and warm it before the fire. Don't go to bed in wet or damp clothes and keep sleeping clothes loose for best circulation. Wear a scarf around your head so that you don't exhale directly into the sleeping bag.

In mountain country camp well up on valley slopes, preferably near a creek—it's warmer than on the valley floor.

In the summer, camp on high dry ground away from woods and streams where flies and mosquitoes will make your life miserable. Ridge tops, the shores of cold lakes or spots that get an onshore breeze are the most comfortable. A good rainy weather shelter can be made from a parachute and a number of twelve to fourteen foot long poles; it also makes a good permanent base, for you can cook, eat, sleep, dress and make signals without going outside.

Don't sleep on the bare ground in summer either, unless you have to. Then scoop out depressions in the ground for your hips and shoulders.

Obstacles to summer travel in the Arctic are dense vegetation, rough terrain, insects, soft ground, swamps, lakes, deep and wide rivers. In winter deep soft snow, dangerous river ice, bitter weather and a scarcity of native foods make traveling tough. In the mountains, care should be taken to avoid the hazards of avalanches prevalent mostly after heavy snowfalls and in sunshine. When crossing glaciers, be on constant lookout for crevasses often hidden under coats of snow. If traveling in groups, rope yourselves together. Try out snowbridges by poking with pole or ice axe. Always cross a snow bridge at right angles to its direction and creep or crawl if not wearing snowshoes.

If you are traveling down a frozen river, watch out for sections of thin ice. Worm your way across on your stomach if you don't have skis or snowshoes.

In the Arctic winter, exposure to cold is the greatest health hazard. It is important not only to wear enough clothing, but to wear it properly. Insulation is the secret. Several thin layers, the outer layer wind-proof, loosely worn will keep you warmer than a single tight and heavy layer. Clothing which fits too tightly around waist, wrists and ankles only cuts off circulation and defeats its purpose.

Sweating is dangerous because it leads to freezing. When you are exerting yourself, open your clothes at neck and wrists and loosen at waist. If you're still warm take off a layer or two. Put back immediately as soon as you cool off or stop work.

Extra boot insulation can be provided, or the lack of socks overcome, by stuffing shoes with dry grass or kapok from plane seat cushions. Mukluks, socks and insoles are best in dry cold; shoepacs best in wet country.

Clothing should be kept dry. Beat out the frost before warming on racks in front of the fire. Try wearing one or two pairs of mittens inside of a windproof shell and do everything with mittens on. As an extra precaution tape all metal surfaces you are likely to touch: pistol trigger, tool handles, etc. If you touch metal with bare hands, don't pull and tear off skin. Warm slowly to remove.

Clothing should be kept in good repair; missing buttons sewed on promptly; holes mended. Keep it as clean as possible.

Protect yourself against wind by wrapping up in parachute cloth and getting behind shelter. Wear a face cloth by pinning a handkerchief or piece of parachute across the lower part of your face. At night pile all spare clothing loosely on top of you.

Unless you are completely exhausted you won't freeze to death in your sleep. Alcohol isn't much use in preserving body warmth; as a matter of fact, it speeds the loss of body heat.

Freezing to death is caused by prolonged exposure to cold and is hastened by insufficient food and fatigue. If your food supply is low, take it easy.

For partial freezing or frostbite, indicated by stiffness, loss of feeling and white or grayish aspect of area, thaw gradually with warm hands if the frozen member is face or ears. In the case of a frozen hand, thaw out slowly under armpit. Frozen feet can be warmed against the skin of companions or warmed in your hands. But don't rub; apply snow or ice. Don't thaw in hot water or before a fire. Severe pain is a sign that warmth is being applied too quickly. Apply sulfanilamide crystals to deeply frozen areas. Wrap in sterilized bandages and keep clean.

Blisters, which sometimes result after a part has thawed and swelled, should not be opened. Frozen feet should be kept elevated and at rest. Carry frozen hands or arms in a sling.

Snow blindness comes from glare on snow and can happen even when the sky is overcast. It starts with a burning or sandy sensation of the eyes, redness, headache, and poor vision. Put moist compresses on and cover with bandages.

Carbon monoxide poisoning usually occurs without warning and results in unconsciousness and death. If you have nausea, pressure at the temples, throbbing pulse, get into the fresh air at once; keep warm and rest. If treating an unconscious case, use artificial respiration or oxygen if available.

Sunburn is also something to be avoided in the Arctic. Keep covered in bright sunlight and use sunburn ointment if you have it.

Aviators and seamen alike dread the day when circumstances will force them to take to the sea in open boats. War has increased a hundredfold the perils of the oceans; it has sent a thousand times the number of men flying and sailing over them. As a result most of the emergency gadgets have been designed for sea survival; with the men who devise them working, as it were, in a sort of mental hair-balanced scale weighing the value of the equipment against the odds of its weight and space consumption.

The Coast Guard, which in wartime leaves the Department of the Treasury to work with the Navy, early in the war tackled the job of re-equipping the lifeboats of the Merchant Marine and insisting on merchantmen carrying the necessary number of life rafts and floats. One of their first surveys revealed the inadequacies of peacetime equipment of such small craft—the conventional, seldom inspected water containers and the insufficient rations of hard tack and chocolate. Now each American merchant ship which sails the seas carries a number of lifeboats, rafts and floats according to Coast Guard specifications for its tonnage. And each small craft is stocked under the same regulations with the following emergency equipment:

- Blankets, 4
- Boathook
- Bucket
- Canvas hood and protective curtain
- Chart
- Compass
- Daytime distress signals, 4
- Distress signals, 12
- Ditty bag
- Drain plugs
- Drinking cups, 2 (1 graduated)
- Electric water light
- First-aid kit
- Fishing kit
- Flashlight, extra lamp & 3-cell battery
- Hatchet
- Illuminating oil, 1 gal.
- Lantern, 2 extra wicks
- Life line
- Life preservers, 2
- Line
- Massage oil, 1 gal.
- Mast and sail
- Matches, 2 boxes
- Oars, 5
- Painter
- Provisions, 56 oz. per person
- Rowlocks, 5
- Sea anchor
- Signaling mirrors, 2
- Signal pistol, 12 cartridges
- Storm oil, 1 gal.
- Water, 10 quarts per person
- Wooden bullet-hole plugs, 25

The Air Forces have had a tougher job in providing emergency equipment. In the larger planes the additional space has been used to greater advantage; but in the crowded confines of combat planes, even one more piece of equipment can be added only at the cost of something equally essential. Coast Guard planes, for instance, on patrol duty along the northern continental coasts and Greenland, fly without de-icing equipment, though ice formations are a continual hazard, because the de-icers cut down flying speed.

Even with the maximum of equipment, sea survival is still a matter of ingenuity and courage, and survival education for airmen stresses both in every instance. The sea does not level men. It brings out the leader in a group, or the stronger in spirit of two or three. It makes it possible for one man to ration slim stocks of food; to deny a sip of water to a thirsting comrade, to marshal the flagging spirits of men to whom death looks more inviting than another hour on the ocean.

The maximum time that most land-based planes stay afloat after being ditched is three minutes—that's the maximum. Generally it takes considerably less time for a plane to sink leaving only an oil slack and a few pieces of flotsam to mark its wake. And the first thing a ditched crew does when hitting the water is to get out of the immediate vicinity of the plane as quickly as possible, to avoid being sucked down with it.

"Survival's" instructions for ditched airmen says:

The first thing to do after taking to the rafts is to conduct a search for any men who might be missing. The entire area near the crash should be looked over sharply. Many times missing men have been wounded and are unconscious and a search in the direction toward which waves are moving often turns up the inert body of a crew member floating low in the water. If there is more than one raft they should be strung together by 25-foot lengths of rope. Rafts should be checked for inflation and leaks, and possible points of chafing protected by patching or temporary covering of some sort.

It goes without saying that getting on the air as soon as possible is of immediate concern. The Gibson Girl—emergency radio—has been provided for just this purpose and is your best signal aid. Instructions for its use are on the set and on the tube container for kite and balloons. The Gibson Girl has a sending radius of 250 miles; but signals have been picked up 400 miles from the established position of a life raft. Don't send within 250 miles of enemy positions unless briefed to the contrary. Signals should be sent during the three-minute International silent periods which start at 15 and 45 minutes after each hour (Greenwich time), or such other periods as are used by monitoring stations in the area, or when a friendly plane is heard or sighted. Crank the Gibson Girl steadily so that rescuers can get accurate bearings.

The ground wire should trail in the water; but make certain that the antenna is clear of the water. During storms or in the presence of lightning take the antenna down. In winds over seven miles an hour, the kite can be used. On windless days use the hydrogen balloon. *Warning: Don't smoke when using the hydrogen generator; don't spill the chemical contents—they will burn you and injure the raft.*

Other signalling devices should be put in readiness for instant use in case a friendly plane or ship is sighted. Signalling should be practiced with the mirror in the life raft kit according to the instructions printed on it. As a substitute, a pocket mirror or any bright piece of metal will do. Punch a hole in the middle of the metal for sighting and if help is sighted keep signalling until signals are acknowledged.

The Very pistols and flares are for night use. Don't waste them; use colored signals in daytime to attract nearby rescuers.

A trail can be blazed by spreading blobs of sea marker at two or three hour intervals during the daylight. Except in very rough seas, these spots of dye remain conspicuous for about three hours. In friendly areas, the powder should be used during the day to make a strip at least one hundred yards long. Other daytime signals are the camouflage tarpaulin waved yellowside up; a sail hoisted on a raft makes it more easily seen than a sailless one; and shortening the lines between rafts so that a larger object is presented to the searchers' eyes.

At night a flashlight or blinker signal light of the radio can be used for signalling. Any light, as a matter of fact, can be seen over the water for several miles. In the absence of any sort of signal light, splashing and churning the sea with paddles will make a large luminous patch easily seen from the air and some raft paddles and oars are coated with a material which will reflect the beam of a searchlight at night.

At night or in fog, the police whistle, standard in most emergency kits, can be used to signal surface vessels or people on shore, or to locate another raft.

But don't shout, or move around unnecessarily. Life rafts capsize easily and excitement uses up energy and makes heavier demands on the system's food and water stores.

With the immediate concern of the raft or rafts taken care of, the condition of the men themselves should next be carefully gone over, and men suffering the most likely injuries such as cuts, bruises, fractures, concussions, internal injuries and burns give the following first aid:

To stop bleeding: Place sterile pad directly on wound and apply pressure by hand or firm bandage. Elevate limb if bleeding continues and use tourniquet if limbs are badly crushed or bleeding will not stop otherwise. The tourniquet should be placed between the injury and heart and released at fifteen to twenty-minute intervals for a few seconds. When the bleeding stops the tourniquet should be loosened but kept on in case of further necessity.

If the breathing has stopped, pull the victim's tongue out to prevent danger of choking, and then apply artificial respiration. A fracture of the skull can be determined by unequal size of eye pupils, bleeding from ears or into skin around eyes. For any head injuries, the head should be kept elevated if possible and the patient kept warm and dry and handled gently. Morphine should not be administered to men with such injuries. Artificial respiration should be kept up at normal rate until breathing is restored or the victim is unquestionably dead. Listen for the heartbeat against bare chest. Keep patient quiet when breathing starts and if oxygen is available administer it at this time.

Chest wounds through which air can be heard in a sucking sound should be dusted with sulfanilamide crystals and bandaged tightly when the patient exhales.

All personnel may suffer some shock. Acute shock can be determined by pale, cold skin, sweating, rapid breathing and weak pulse with sometimes confusion or unconsciousness. Sometimes, however, none of these symptoms exist.

Men in shock should be treated cheerfully and reassuringly. They should be stretched out as flat as conditions permit with the feet elevated and the head lowered. If conscious and not injured internally warm drinks—not alcohol—can be given, and in any case, they should be wrapped for added warmth. If the victim is in pain from a severe injury, morphine injection (syrette) should be given according to the directions on container.

Men having fractures should be handled with extreme care to avoid further injuries. Don't remove the clothing from fractured parts. If an open wound exists, cut the clothing away and treat it before applying splint. Splints can be improvised from pieces of equipment, tight roll or clothing. Pad with soft materials and keep casualty lying quiet. Morphine can be injected to ease pain.

For sprains—bandage and keep part at rest. Wounds should be treated as carefully as possible to avoid infections. They should not be touched with fingers or dirty objects, or sucked. Only minor wounds should be treated with iodine; in the tropics, iodine should not be used at all. Sulfanilamide should be sprinkled on open wounds and a bandage applied firmly but not tightly over them.

In the case of burns don't open blisters or touch burned area with fingers. Apply burn ointment and sulfa crystals. Tie a thick gauze pack on firmly and leave on without changing. For severe pain from burns, morphine injection can be used. The burned part should be kept at rest.

With all injured crew members treated as well as possible by means of first aid, the officer in charge can then attend to the rationing of food and water and assign duties to the different men. No food or water is taken for the first twenty-four hours. And if the plane crew has had time before the plane was ditched, this won't be so hard. Airmen have been taught to cram all the food they can on the way down and fill themselves with water from the plane's drinking supply—it gives the body an extra store of liquid energy. Of course, injured men are excepted from the 24-hour ban.

A log should be begun by recording the navigator's last fix, time of ditching, names and condition of personnel, ration schedule, winds, weather, direction of swells and other navigation data and an inventory of all equipment.

Then the area of the crash should be combed for the salvage of all plane debris. All rations found in the vicinity should be stowed aboard the raft, as well as canteens, thermos jugs, and other containers, parachutes, seat cushions, extra clothes and maps. The tube containing the kite and balloons for the emergency radio especially should not be overlooked. All the equipment should be then secured to the raft by lashing or stowed in the raft pockets and kit containers. And these last should be kept closed when not in use. Such items as compasses, watches, matches, lighters, flashlights and signals should be kept dry.

If the ditching has been made in a cold ocean, the most important thing is to stay dry and to keep warm. A windbreak and spray shield can be rigged up from tarpaulin and the crew should huddle together on the floor of the raft for extra warmth. Extra tarpaulin, sail or parachute should be spread blanketwise over the group and mild exercises should be taken regularly. The hands should be flexed often and the toes bent and opened; shoulder and buttock muscles should be moved regularly and the feet raised periodically for a minute or two. Grimacing and moving the facial muscles frequently is a means of detecting frostbite and the hands can be warmed occasionally under the armpits. If you're shivering, that's good—it's nature's way of generating heat quickly.

Men who are suffering from exposure to the cold should be given extra rations. In northern oceans in the winter, frostbite most often occurs when wet skin is exposed to the wind. Face, ears, hands and feet are most susceptible and an effort should be made to keep them as dry as possible and covered. If shoes are tight, however, they should be removed and the feet wrapped in dry cloth.

Dry clothes should be shared with those who are wet and they should be given the most sheltered portion of the raft. Cold and wet crew members should be allowed to warm their hands and feet against the bodies of their dry companions. All extra clothing should be put on and if there are no exposure suits on board, extra clothes should be draped around head and shoulders. Clothes should be kept loose and comfortable. The floor of the raft should be kept as dry as possible and extra insulation can be provided by lining raft floor with extra canvas or clothing not in use.

In a warm ocean protection from the sun is most important. The sun has done dreadful things to men when they have been unceasingly exposed to its merciless rays. Exposure to the sun also increases thirst and evaporates precious water. In only one type of raft, the one-man, mastless raft, is it impossible to rig up some sort of sunshade. In the multi-place raft, two oars can be lashed upright at either end, a rope stretched between them and the tarpaulin thrown over it to provide shelter. Some space should be allowed to remain open around the bottom for ventilation. In friendly waters, the tarpaulin should be used yellow side up in order to attract attention; in enemy territory, the blue side should be placed upward in order to avoid detection. In a one-man job with mast, a sunshade can be improvised by using the mast and stays to support the tarpaulin. In the mastless type, unless driftwood or other debris is found, however, it is impossible to erect a canopy.

In that case, the only thing to do is to keep the body as well covered as possible. No clothing should be thrown away; sleeves should be rolled down; collars fastened and socks pulled up. If you have a hat, wear it; if not, improvise one out of extra cloth or canvas. Make a shield for the back of the neck and either wear sun glasses or, in their absence, improvise a pair in the manner outlined in desert survival.

Down at sea is bad enough; but down in enemy *waters* is double trouble. If you are detected, the first thing to do is to destroy log book, radio, navigating equipment, maps, signalling equipment and firearms before you are captured. If subjected to enemy strafing, jump overboard and submerge.

In order to avoid detection in enemy waters don't travel in the daytime. Throw out the sea anchor, deflate the raft as feasible, lay low in the bottom and covered up with tarpaulin, blue side up, and lay doggo until nightfall before paddling or hoisting sail. The radio should not be used within 250 miles of enemy shores unless you are sure a friendly base is near. Don't use signalling devices on passing ships or planes until they have been definitely identified as friendly or neutral.

At sea your raft serves the same purpose that your feet do in jungle or desert: it is the only means of getting you where you are going. Only its thin rubberized floor keeps you and the ocean apart: only the air in its bulgy walls keeps the floor floating. Make your raft shipshape and keep it that way. The first thing is proper inflation. If the main buoyancy chambers are not firm, top off with pump or mouth inflation tube. Make sure that the valve is open before pumping—to open turn to the left. Unless there are injured who must be stretched out flat, inflate the cross seats. Avoid over-inflation, which is apparent when buoyancy chambers are drum tight; they should be just well rounded. The valve should be closed tightly and the raft checked daily for inflation. On hot days, a little air should be let out, since hot air expands; in cold weather, or when it cools, add a little air.

Prevent chafing of the raft at all times. If there is a sea anchor out wrap a piece of cloth around the rope where it lies against the raft. (Sea anchors or drags can be improvised from the raft case, bailing bucket or roll of clothing.) In good weather don't wear shoes in the raft, but make sure that you tie them in. And watch fishhooks, knives, ration tins and other sharp objects to see that they don't snag the raft, and keep them off the bottom.

In stormy weather rig a spray shield in order to keep the raft as dry as possible. The raft should always ride as well balanced as you can make it. Heavy men should stay in the center; the sea anchor will help to keep the windward side down, and all men should stay seated.

Daily checks should be made of all raft seams, underwater surfaces and valves—the most likely spots for leaks to occur. The wooden or metal plug in the mending kit can be used for temporary repairs. Leaking valves can be plugged with chewing gum and adhesive. Permanent patches should be applied in the following manner as soon as the surface is dry:

Clean surface first, then roughen lightly. Cut a patch to correct shape and size and roughen one side. Apply cement from repair kit to patch and leak area and when partly dry, stick the patch in place, holding it until cement sets.

To repair leaks below the water line, wait for a quiet day and then turn the raft over. In most multi-place rafts, there are two separate buoyancy chambers; if one is damaged, keep the other fully inflated to obtain necessary buoyancy.

When it comes to rationing the water supply, the officer in charge has almost a mathematical calculation to make. He will have to figure the water on hand, output of sun-still and chemical desalting kit. (The sun-still is a plastic bag containing a black plastic sponge which soaks up the water condensed by the sun rays. The desalting kits are two or more plastic bags which can be filled with salt water, a chemical tablet dropped in and the purified water after a few minutes poured off into the other bag.) Beyond this he has to make an estimate of the time it will take to reach land, the chances of rain, of rescue, and figure out the daily ration on the basis of the number of men and their condition.

An inactive man, taking all precautions to keep cool and to conserve the body's fluids, can stay alive on a raft for about two weeks on a daily ration of two ounces—one-eighth of a pint—of water. Severely injured men should get increased rations.

The water ration should be issued in the early morning and evening. The lips should be moistened first, then a small sip taken and held in the mouth for a few minutes before being swallowed.

To conserve as far as possible the body's water supply, observe the following rules:

Soak the clothes in the sea and wring them out before putting on again.Don't douse yourself with water—it makes the bottom of the raft wet. And don't go overboard to cool off. Dry your clothes before nightfall.

In hot weather keep quiet. Sleep as much as possible.

Chew gum or suck on a button to keep mouth moist.

Don't drink urine.

Don't drink pure sea water—it is poisonous. In very hot weather, or if you have been sweating profusely, it is safe to drink a small quantity of *diluted* sea water. Dilution should be made by adding one part of sea water to not less than six parts of fresh water.

The sun still should be rigged and put to use at once. The chemical kits and emergency stores should be used only when it is impossible to use the sun still or to catch rain water. The tarpaulin can be used to catch rain water, but it should first be washed in sea water to remove crusted salt or a little of the first batch of fresh water caught in it should be thrown away for the same purpose. Fill all the containers aboard; then drink all you can hold. Practice holding the tarpaulin to catch rain water; place heavy objects in the center to prevent flapping.

In some localities dew can be collected by rigging the tarpaulin as for a sunshade but with the edges turned up.

In northern regions, old sea ice will provide potable water; and water from icebergs is fresh. Be very careful approaching icebergs—they sometimes break up. *They are dangerous.*

Next to water comes food. If your water ration is a quart or more per man per day, you can eat anything you have or can catch. If the ration is a pint per day or less, eat only the hard candy, fruit bar, or life raft "pemmican" in emergency kits. Don't eat birds, fish, shrimp, crabs or the meat in rations unless you have at least a full pint every day. If you have no water, don't eat anything.

Rations should be opened one can at a time and the cans and waxed paper saved for future use as containers and waterproof wrappers.

The shock and fear of a crash landing at sea and the experience of living on a rubber boat cause many hazards to mental and physical health. Fear is normal among men in such a dangerous situation and admitting it helps men to carry on in spite of the fear.

Sometimes, though, the fear natural in such situations, combines with fatigue and exhaustion to lead to a mental crackup. This condition is found most often in older men and in men who were not in the best of health before their experience. Both the attitude of companions in the raft and of the person affected can do a lot to ward off crackups in the early stages.

Early signs, for instance, are extreme nervousness, excessive and violent activity or depression. The best antidote is plenty of rest and sleep and constant concern with routine raft duties. For intense irritability and fits of temper —let it go. Don't wall it up inside; get it out and over with or do something that will take your mind off it.

However, when a mental disturbance has progressed to the hysterical stage, boat comrades should let the man cry or laugh as he wants unless he is demoralizing the others, or is exhausting himself. Roughness and unkindness, on the other hand, generally aggravate the affected person, make him sullen and angry. For a violent case, however, an injection of morphine is about the only recourse.

Keeping a rubber boat dry is pretty hard but every attempt should be made to do it. When the feet are constantly in water or in wet shoes and socks, immersion foot generally results. It's the same thing that doughboys call trench foot. Its first signs are tingling, numbness, redness and swelling. If it is allowed to progress beyond this stage without regularly drying and rubbing the feet, and elevating them for about a half hour a day to restore circulation, the second stage, red blotches and blisters appear. Don't break these blisters. Sprinkle sulfa powder over the affected area and treat as above except for rubbing. Substitute toe exercises instead. On landing, if someone is present to carry you, don't attempt to walk, as great damage can be done to the tissues while in this condition.

Reflection blindness and sore eyes often result from the glare on the water. The eyes get bloodshot, inflamed and painful. Wear sun goggles if you have them. If not, make an eye shield from a piece of cloth or bandage. The boric acid ointment from the first aid kit is helpful; or in its absence moisten pads with sea water and put over the eyes before bandaging.

From long immersion or constant wetting with sea water, salt water sores sometimes appear. They look and feel like boils, but don't open or squeeze them. Use sulfanilamide crystals on them.

For raft sea-sickness, which can sometimes be violent enough to cause death, try lying down and changing the position of your head. Don't eat or drink while sick and take seasick remedy if it is available.

Constipation is normal in raft life. Don't worry about it and don't take laxatives even if you have them. They will only dehydrate you. Just as normal is difficulty in urinating and its dark color.

On the containers of the fishing kits which are part of standard life raft equipment is an inscription: *Emergency Fishing Kit. Open Only for Actual Emergency Use.*

The kit when unrolled is a biblike apron, twenty-eight inches wide and fifteen inches long, made of sturdy olive drab cotton. It contains twelve pockets into which is fitted everything the well equipped fisherman should have if he'd like a try at everything that swims in the ocean with the possible exception of such sea giants as whales and walruses.

The instructions that accompany the kit recommend that one man be put in charge of the fishing equipment and that he wear the apron when it is in use. When not being used, the equipment should be put back in its container so that it doesn't get scattered about. How to use each of the seven separate rigs and the rest of the tackle:

Rig No. 1—Hook and line—the length of line is 100 feet. Bait the hook with a small piece of pork rind (contained in the kit) as wide across as the bend of the hook, and a little longer. If fish are very small, make the bait small too. If you have nothing better, slip or tie a white or pearl button off your shirt and keep it moving, sometimes slow, sometimes faster.

Rig No. 2—Mackerel jig—The length of line is 100 feet. Before fishing, scrape metal of jig until it is bright. Troll (drag) this jig behind your boat when in motion. It is intended to imitate a fish. Keep it moving.

To use a jig without bait, let out twenty-five or fifty feet of line. But if the fish do not bite, hook through one end a two-inch piece of pork rind. A narrow strip cut from the white belly of a fish is excellent, or a small live fish may be best of all. Hook the fish through the back and let it run.

When you have caught a fish or a bird, a small piece of fish or meat is usually better than pork rind bait. If you have no other bait, cut from your shoe a small, narrow strip of leather or canvas, an inch long for small fish or a bird, a longer piece for bigger fish. Hook it through one end and keep it moving.

When your boat is not traveling through the water fast enough to keep the jig near the top, let it sink to different depths and keep pulling the line in, either steadily or with jerks. Try both.

When the boat is moving too slowly to keep jig near surface, take hold of the line about four feet from the jig, whirl the jig around your head on the short line and cast it far out. Then pull in as fast as you can, either steadily or in jerks. But first see that the end of the line is firmly held by another man, and that no one will be hit by your whirling jig.

The jig can also be used for deep fishing with pork rind bait or a piece of fish or bird. Try it at different depths.

Rig No 3—Feather jig—Same instructions as for Rig No. 2.

Rig No. 4—Hook, line and sinker. For bait fishing near the boat or deep down, bait the hook with pork rind, fish, or meat. If you let this line down full length and get no fish, tie another line of about the same size to it securely and try deeper. If the lead now on the line will not sink, use extra lead also.

Rig No. 5—Grapple for snagging fish. Very useful if you have no bait or if fish will not bite. When fish are around or close to the boat, throw this grapple beyond or among them, or drop it near them, and jerk it sharply to hook them.

Rig No. 6—Feather jig. Same instructions as for Rig No. 2.

Rig No. 7—Small harpoon or spear. Very useful for taking small sharks, turtles, and fish that will not bite. Also for birds that light on the boat or swim nearby.

Let another man hold the end of the line tied in the eye at the end of the shaft. Hook the offset in the middle of the shaft over the end of an oar blade. Hold the line tight in one hand to keep the harpoon in place. Jab with this harpoon. Don't throw it. With a knife you can shape either end of an oar or paddle, or a boathook, or stick of wood, to fit this harpoon.

When you have struck and a fish is fast, be very sure to throw the oar, boathook or other handle back into the boat. Otherwise you might lose it. Then fight your fish with the line.

If a big fish is hooked and is fighting the line near the boat, harpoon it quickly. You will have a double chance to save it. Be very careful not to harpoon sharks or other fish too big to handle.

Other articles in the kit: Pork rind bait. Very important. It will turn white in the water. Do not waste or lose this bait. Use as directed on the kit to be effective.

Dip net. Very useful to catch small fish for bait or food. Unfold and open out. Move net slowly under the fish and then lift. Do not untie either line. Hold line at front of net in left hand and use it to pull net through water while holding handle in right hand. If it falls overboard, this net will not float. Do not eat small crabs and shrimps that gather around a light at night and sometimes are so thick they turn the water red, unless you have plenty of fresh water. They are salty and will increase thirst.

Knife. Keep a lanyard fast to the knife and tie other end when in use. If it falls overboard, this knife will float.

Whetstone. Keep your hooks sharp. Dull hooks catch less fish.

Spare hooks ready to tie on line, and extra lead.

Gloves. To protect your hands from being cut by the line or when handling fish in the water or in the boat. Otherwise the line may hurt your hands badly. Many fish have sharp fins. The safest place to hold a fish is just behind the head or just above the tail.

Any fish you catch at sea is edible with the exception of jellyfish, which are poisonous. Poisonous fish are found only close inshore. If the fishing kit is lost, hooks can be made from insignia pins, pencil clip, shoe nails, pocket knives, fish spines, bird bones, pieces of wood; as tools use pliers found in patching kit. Make hooks small. Make fish line from cord in emergency kit, shoe laces, parachute lines, or thread from clothing.

Save fish and bird guts for bait. Try fishing at different depths; keep bait moving; try trolling or casting. A handy spear for large fish which cannot be caught with a hook can be made by tying a knife or the harpoon point from the fishing kit to an oar. If the dip net from the fishing kit is lost make a net from mosquito headnet, parachute cloth or clothes fastened to oar sections—held under the water and scooped upward it will serve to snare small fish, crabs or shrimps. At night, a flashlight shone on the water, or a mirror reflecting moonlight on the surface, acts to attract fish within range of net, hook or spear.

As you will be fishing from a small, easily capsized rubber raft, whose bottom is only a thin layer of rubberized material, some precautions will have to be taken when fishing. The first is not to wind the line around the hand or body or tie it to the raft. Have another man in the boat hold the end of the line; don't pay out all the line and wear gloves so that if you hook onto a big one your hands won't get cut. In this case, also take care that the line does not cut into the raft.

When landing a catch use the harpoon or net. Be careful of teeth and fish spines—they can cause a nasty and painful infection. Kill fish with a blow on head. Watch out when spearing or shooting large fish; they can be dangerous when wounded.

When it comes to eating your catch observe the following rules:

Clean and gut all fish immediately. Eat fish right away before it spoils. If you want to preserve fish left over, cut into thin strips and dry thoroughly in the sun.

Don't eat fish eggs or liver.

Don't eat fish which have an unpleasant odor, pale, slimy gills, sunken eyes, flabby skin or flesh that stays dented when pressed.

Crabs and shrimp can often be found in masses of floating seaweed. Shake them out over the bottom of the boat.

All the sea birds are edible, even if on the strong and gamey side. They can be caught sometimes by drawing a baited hook across the surface, or throwing it into the air.

Practically everything on sea turtles but shells, claws and head is good eating or good for something. Blood and body fluids are good to drink. Stomach and intestines make good bait. Eat the liver at once—it spoils quickly. Even the fat is edible. Kill turtles by shooting in the head or get them by snagging with a hook and kill with a blow on the head. Watch out that they do not bite or claw the raft.

Now about sharks. To begin with, they are not the bugaboo they are thought to be and the chances of being attacked by one are very small. But there is a chance and the risk involved can be reduced by knowing what to do and how to do it. "Survival" has this advice to offer:

"If a single large shark threatens at close range:

"a. Use a strong regular swimming motion; try feinting toward the shark—he may be scared away.

"b. Don't swim away directly in the shark's path; face him and swim quickly to one side; outmaneuver him.

"c. Kick or stiff-arm a shark to push him away, or grasp a side fin and swim with the shark until you can veer away from him.

"d. Make loud sounds by slapping the surface of the water with cupped hands; use regular strokes.

"e. Use a knife at close quarters in a showdown."

Attacks from sharks are most likely to occur in warm waters and in order to avoid any close contact with sharks a sharp lookout for them should be maintained at all times.

If you are in the water, clothes and shoes should be kept on. If in a group and threatened by a shark, form a tight circle facing outward and ward off attack by kicking or strong arm. If in rough water, tie yourselves together.

Play doggo when sharks are in the vicinity, floating to save energy. If it is necessary to swim, use strong regular strokes and don't thrash around frantically. If you are alone, stay away from schools of fish.

When you are on a raft, don't fish when there are sharks around; cut loose any fish caught when there's a shark in the neighborhood; don't throw overboard any waste from fish. Remember the Tunnel of Love advice: Keep feet inside boat. If a shark decides to nudge around the boat and it looks like his sharp teeth or tail blows will damage it, discourage him by jabbing with an oar in the snout or gills. Take care not to break the oar and don't go in for roundhouse swings or you'll upset the raft. Firing a pistol sometimes frightens away sharks; but aim above his head —sharks are extremely dangerous when wounded.

Before going in swimming or making a landing, look around carefully for sharks.

When you're at sea the question about whether or not to travel is automatically eliminated. Whether you like it or not, your craft will move. Where it will go is largely the result of wind and ocean current, modified by the use of oars, paddles, tiller, sea anchor and sails. The best plan, therefore, is to try to use wind and current to your advantage as far as is possible within the narrow navigational limits of the standard rubber life raft.

Location can be generally ascertained from the flight data and if you have come down on course, it is best to try to stay on the flight track. Regular air and vessel routes, for one, generally lead somewhere and staying as close as possible to one increases your chances of being spotted.

In any event a large target should be your aim—a continental shore, large island, or a group of smaller ones. Trying to hit a pinpoint on the map with a rubber boat is just about equal to the well known chances of locating the needle in a haystack. But whatever course you finally decide on, stick to it.

About the third thing the officer in charge will have done after the crash and assembly in the raft or rafts is to assign watches. They should not exceed two hours and a lookout should be kept posted at all times day and night. His job is to watch for signs of land, schools of fish, birds, signs of chafing or leaking of the raft. He should be tied to the raft with a ten-foot line. All men should serve on watch except those badly injured or exhausted.

If the current is going in your direction but the wind is unfavorable, a sea anchor will help to counter the effect. The raft should also be deflated slightly so that it rides low in the water, offering the least wind resistance, and the men should huddle as close to the bottom as possible. Traveling on ocean currents will not be fast—they run only about six or eight miles a day—but it will be fairly steady.

No matter how experienced a sailor you are, you won't be able to sail a rubber boat into the wind. But anyone can sail one downwind, and if the wind is blowing directly toward your destination, rig a sail, inflate the raft fully, sit high, take in the sea anchor, and use an oar as a rudder.

The large multi-place rafts can be sailed ten degrees off from the direction of the wind. A sail can be set up by using two oars with their extensions as mast and cross bar. If the regular sail is not available, substitute either the tarpaulin or one or two layers of parachute cloth. If there is no mast socket on the raft, tie the oar securely to the front cross seat and brace it. Even if there is a socket, pad it to prevent chafing or punching a hole in the boat's bottom. A good mast step can be made from the heel of a shoe with the toe wedged securely under the seat.

Both corners of the sail should not be tied down. Keep one edge free and held in the hand so that a sudden storm or gust of wind won't rip the sail, break the mast or capsize the raft.

Other precautions should also be taken against capsizing. In rough weather keep a sea anchor out, sit low and distribute the weight so that the weather side is held down. Don't sit on the sides or make sudden moves without warning the other occupants. If there is more than one raft and the seas are heavy, throw out a sea anchor from the bow of first raft. Keep the boats tied together with approximately twenty-five feet of line, adjusting the line to suit sea. Keep the sea anchor line long: the sea anchor should be seen in the trough when the raft is at the crest of a wave. In very bad weather keep a second sea anchor ready to be thrown out in case the first that is out breaks loose. When the sea anchor is not in use, it should be kept tied to the raft and stowed aboard in such a way that if the raft capsizes it will be released to hold the boat.

Life vests should be kept on constantly.

If, in spite of all these precautions, the raft capsizes, it can be righted by any of the following means. Most multiplace rafts, for instance, have a righting rope. It should be tossed over the bottom, then you can move around to the other side, grasp it and pull the raft over. If there is no righting rope and one cannot be improvised from sea anchor line, belt or shirt, slide up on the bottom of the raft, grab the life line on the opposite side, and slide back into the water, pulling the raft back and over with you. All new rafts, however, have righting handles on the bottom.

All the newer type rafts also have boarding ladders for entering the raft from the water. If, however, as sometimes happens, your particular raft does not happen to be a late model, you can still get aboard by grasping the seat and hauling yourself in over the end. If a wind is blowing, board with the wind at your back. If a group is getting aboard, one man should hold down the far side while the rest clamber aboard and then enter himself by any of the above means.

Getting aboard a one-man raft is sometimes made easier by removing shoes and tying them in the opposite end. In warm weather, all the clothes may be removed and tied down before the attempt to climb aboard is made. One-man rafts are more easily entered from the narrow end by sliding up as nearly horizontally as possible.

In the tropics, mirages sometimes raise false hopes of land. You can generally tell whether it's the real thing or a mirage by viewing it from different heights: if it's a mirage, it will disappear or change appearance or elevation. The real thing is generally manifested long before it appears by a fixed cumulus cloud in a clear sky or, in a sky where all other clouds are moving, by a cloud hovering over or slightly downwind from an island. In the tropics a green tint in the sky is sometimes a sign of nearby land. It results from the reflection of the sun on the shallow waters of lagoons or coral reefs.

In the Arctic, snowfields or icefields give away their presence by a light sky; open water reflects a dark gray sky.

Other signs of land are driftwood and floating plants; sea birds in flocks of ten or more indicate land within fifty miles. And the flight of flocks of birds at dusk and dawn usually point in the direction of land. Land is also indicated very often by decreasing depth of water. If the color lightens from deep green or blue to lighter shades, it is getting shallow and may indicate land nearby.

In rain, mist, fog and at night land may be detected if you are drifting past it by odors and sounds. Mangrove swamps smell musty; the odor of mud flats and burning wood will carry great distances. Long before shore is seen, the roar of the surf can be heard. And the continued cries of sea birds tell that their roosting place is nearby.

The actual business of getting ashore, either in the raft or by swimming, is not something to be rushed into. *Take your time.* Wear at least one thickness of clothes and keep your shoes on. The side or breast stroke is best because it uses less energy. If you have to land on a rocky shore, or one behind coral reefs, pick out the most likely looking spot. In the case of rocks, select one where the waves rush up on the rocks and avoid the places where they explode with a high white spray. Swim in slowly; you will need your strength to hold onto rocks; and advance into a large wave behind the breakers. If you see quiet water, it will generally be in the lee of a heavy growth of seaweed and you can take advantage of this and crawl over the top of it by grasping the vegetation with overhand movements.

If no quiet water is available, face shoreward and take a sitting position. Put your feet in front and two or three feet lower than your head so that they will absorb shocks when you land or hit submerged boulders or rocks. If the wave you have selected to ride in on doesn't carry you all the way into shore, swim with your hands only while waiting for the next one. Then take the sitting position again. Swimming through the surf can be speeded by removing the life jacket and swimming with it in one hand. Don't abandon it unless forced to do so in order to hold onto a rock.

The same procedure should be used in getting across coral reefs.

In a quiet surf, ride in to shore on the back of a small wave by swimming with it. Just before the wave breaks, shallow dive to end your ride. In a heavy surf, swim forward in the troughs of waves, submerging under seaward waves.

If you are caught in undertow, push off the bottom or swim to the surface and work your way shoreward in the trough of waves as above.

Getting ashore in a raft requires even more care. Taking a raft through strong surf is dangerous. The landing spot should be carefully picked out. If possible, make it on the lee side of an island or of a point of land. The best spot of all is a sloping beach where the surf is gentle. In lieu of that, pick a gap in the surf line and head for it. Stay away if possible from coral reefs—they don't occur near the mouths of freshwater streams—and rocky cliffs. Stay away from rip tides and strong currents which might carry you far out to sea.

If it is necessary to take the raft through the surf in order to land, keep your clothes and shoes on in order to avoid cuts and bruises, and inflate your Mae West properly. Take down the mast and trail the sea anchor out as far as it will go from the stern end. Keep the anchor taut at the end of the line by adjusting it and paddling the raft. This will keep the raft headed into shore and prevent the sea from capsizing it. Paddle hard to keep the raft riding on the seaward side of large waves.

A good method for getting a raft through surf is to have half the men sit facing the others. When a heavy wave bears down, half should row toward the sea until the crest passes, then the other half should row toward shore until the next sea comes along, often all too soon.

Speed is essential against a strong wind and heavy surf to get past oncoming crests and avoid being turned sideways or capsized. Avoid meeting a large wave at the moment it breaks, and in normal surf, without wind, keep the raft from riding up on a wave so rapidly that it is flung into the trough.

When the raft gets close inshore, pick out a good-sized wave and ride in on its crest. Paddle and row hard and don't jump out until the raft grounds. Then get out quickly and beach it.

Avoid landing at night. In wartime, the natural hazards have added peril of quick-shooting sentries, barbed wire entanglements, mined beaches. If you think the land is inhabited lay off shore, send up signals and wait for someone to come out and bring you in.

It seems incongruous and far-fetched to imagine that staid civilian travelers might some day use the wealth of survival information that Uncle Sam has gathered together for the use of his fighting men. But it isn't really far-fetched, when you realize that World War II has already flung us into the air even more precipitously than World War I sent us out on the open roads.